Journal

OF

The Royal Society

OF

Western Australia.

Vol. XV.
1928-1929.

The Authors of Papers are alone responsible for the statements
and
the opinions expressed therein.

Price: £1 15s.

Printed for the Society by
JOHN LEE, ACTING GOVERNMENT PRINTER, PERTH,

1929.

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CORRIGENDA.

Page	Line	
100	9	from bottom for "0.7" read ".07."
101	23	for "geoogical" read "geological."
106	22	from bottom for "higher" read "lower."
109	9	after "imperfect crystals" add "of tapiolite."
110	5	to analysis add "MnO, nil."
„	9	for ".9" read "0.9."

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THE ROYAL SOCIETY OF WESTERN AUSTRALIA.

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Drummond, F. H., 5 *Stone Street, South Perth.*

Proceedings

of

The Royal Society of Western Australia.

Session 1928-29.

ANNUAL REPORT OF THE COUNCIL

FOR

THE YEAR ENDING 30th JUNE, 1929.

LADIES AND GENTLEMEN,

Your Council begs to submit the following report for the year ending 30th June, 1929.

MEMBERSHIP.

On 30th June, 1929, 215 members were on the roll, of whom nine were honorary members, eight corresponding members, 131 ordinary members, 65 associate members and two student members. During the year seven ordinary members and 112 associate members were elected, while 10 ordinary members and six associate members resigned. The names of eight ordinary members and four associates were removed in accordance with Rule 12.

We regret to report the loss by death of two of the foundation members of the Society, Mr. J. J. Dwyer and Archbishop C. O. L. Riley.

MEETINGS.

Eleven ordinary meetings of the Council and two special meetings were held during the year.

FINANCES.

The Statement of the Society's Income and Expenditure during the 1928-29 session, which will be found appended, may be summarised briefly as follows:

During the year the total receipts on account of income, which includes the subsidy granted by the Government, amounted to £288, being £8 3s. 11d. more than that received during the previous session. On the other hand, the current expenditure of the Society's year, including the cost of the Royal Society's Gold Medal, amounted to £335 19s. 7d. The actual excess of expenditure over receipts amounted to £47 19s. 7d. It is estimated that the amount necessary to complete Volume XV. will cost an additional sum of about £60.

The grant received from the Treasury during the year was at the rate of £100 per annum, as in the preceding year, and the Council wishes to express its thanks to the Government for its subsidy. Without the aid of the Government grant the publication of papers in the Journal would have to be seriously curtailed. At present it is possible for the Council to assure Western Australian scientific workers facilities for publication of all original work of merit.

Publications.

Volume XIV., containing the proceedings and transactions for the year 1927-28, has been completed and issued to members and forwarded in accordance with the exchange list. Volume XV., containing the proceedings for the year 1928-29, is well in hand. All papers contributed to the Society during the year are with the printer. The volume should be completed and issued to members early in the forthcoming session.

The Council has to acknowledge its indebtedness to Mr. A. Gibb Maitland for undertaking the task of editing Volumes XIV. and XV., and to express its high appreciation for the manner in which this work has been carried out. The arduous task of editor is but one of many examples of the indebtedness of the Society to Mr. Gibb Maitland. Partly because of these many services, but chiefly because of his great distinction as a scientific worker, together with his many valuable contributions to our knowledge of the geology of Western Australia, the Council has nominated Mr. Gibb Maitland for election as an honorary member.

Centenary Conversazione.

As the Royal Society's contribution to the celebration of the centenary of the foundation of the State, a conversazione was held on the evening of Friday, 17th May, in the Museum and Art Galleries. These were made available by the courtesy of the Trustees. Exhibits of special character, illustrating the development of scientific and technical knowledge during the century, were made as follows: —

Agriculture.—"The Scientific and Economic Development of Wheat Growing and Flour Milling during the Century".

R. G. Lapsley, B.Sc.(Ag.), A.A.C.I.; L. J. H. Teakle, Ph.D., M.Sc., B.Sc.(Ag.), A.A.C.I.; I. Thomas; B. L. Southern, A.A.C.I.; L. Newman, F.E.S.; H. A. Pittman, B.Sc. (Ag.).

Botany.—"Specimens illustrating early Records of the Systematic Botany of Western Australia." C. A. Gardner.

"Native Plants under Cultivation." H. Steedman.

Conchology. "Some Recent and Subrecent Mollusca." Miss M. E. Hendry.

Forestry.—"Forests Products and Timber." W. E. Campion.

Geology.- "Some Geological Maps, 1848-1920." T. Blatchford, B.A.

"Model of the Darlington Area." S. E. Terril, B.Sc.

Meteorology. —"Meteorological Records and Apparatus." W. Stokle. By permission of Mr. H. A. Hunt, Commonwealth Meteorologist of W.A., and Mr. E. B. Curlewis, Divisional Meteorologist for W.A.

Mineralogy. "Progress of Mineral Discovery in Western Australia." E. S. Simpson, D.Sc., B.E., F.A.C.I.

Surveying.—"Maps and Surveying Instruments." J. P. Camm.

Royal Society. -"Design adopted for reverse of Society's Gold Medal." By Miss Enid Allum.

The following lectures were given during the evening:—

"Reflections on Physical Science." By Professor A. D. Ross, M.A., D.Sc. (An address supposed to be delivered on 17th May, 1829.)

"Trees." By Miss E. R. L. Reed, M.Sc.

"The Economic Development of Wheat Growing and Flour Milling." By Dr. L. J. H. Teakle, Ph.D., M.Sc., A.A.C.I.

The Council desires to express its thanks to the Trustees of the Museum and Art Galleries and to all the members of the Royal Society who, by their willing help, contributed to the success of the function.

ROYAL SOCIETY'S GOLD MEDAL.

The second award of the Royal Society's Gold Medal was made to Dr. E. S. Simpson, Government Analyst and Mineralogist. The Medal was awarded by unanimous vote of the Council after receiving a recommendation from a special committee consisting of the President (Mr. W. M. Carne), Professors N. T. M. Wilsmore and E. de C. Clarke, and Messrs. R. D. Thompson and F. E. Allum. Members of the Society were invited to submit designs for the reverse of the medal, and that of Miss Enid Allum was adopted. The preparation of the die and the whole of the arrangements for the striking of the medal were carried out under the supervision of Mr. H. A. Corbet, Deputy Master of the Mint, and the thanks of the Council are due to him and his staff for their services in connection with the matter. The medal was conferred on Dr. Simpson at the Centenary Conversazione by the Vice-Patron of the Society, His Excellency Sir William Campion, K.C.M.G. A statement concerning Dr. Simpson's scientific work is given on pp. XVII. *et seq.*

GENERAL.

The Council has transferred the botanical collections of the former Natural History and Science Society to the Department of Agriculture for the use of the Government Botanist and subsequent incorporation in the State Herbarium, when such is established.

Mr. L. Glauert, B.A., F.G.S., Hon. Librarian of the Society and Curator of the Western Australian Museum, has been nominated by the Council as correspondent of the Society for the Preservation of the Fauna of the Empire.

The following reports of Committees are appended:—

(i) Excursions Committee.

(ii) Housing Scheme Committee.

(iii) The Salinity in Soils Committee; as well as the report of the Hon. Librarians.

W. M. CARNE,
President.

W. E. SHELTON,
L. W. PHILLIPS,
Joint Hon. Secretaries.

ROYAL SOCIETY OF WESTERN AUSTRALIA.

YEAR 1928–29.

Statement of Income and Expenditure to 30th June, 1929.

RECEIPTS.

	£	s.	d.	£	s.	d.
Balance at 1st July, 1928—						
Medal Fund	30	0	0			
General Fund	107	5	3			
Endowment	100	0	0			
Cash in hand	1	7	2			
				238	12	5
Subscriptions—						
1929-30	4	14	6			
1928–29	122	11	3			
1927–28	22	11	6			
1926–27	5	5	0			
1925–26	1	1	0			
				156	3	3
Government Grant, June, 1928 to May, 1929				100	0	0
Receipts from Reprints				12	9	3
Interest on Endowment				5	0	0
Interest on Current Account				7	17	6
Excursion Subscriptions				6	10	0
Total				£526	12	5

EXPENDITURE.

	£	s.	d.	£	s.	d.
Printing—						
To Complete Journal XIV.	82	6	1			
Part Journal XV.	67	17	8			
Card Programs	3	16	4			
Miscellaneous	5	2	9			
				159	2	10
Museum Trustees Fees				14	8	0
Library Shelving				14	0	0
Excursion Expenses				6	10	0
Rent Post Office Box				3	0	0
Expenses Annual Meeting, 1928				18	3	0
Royal Society Medal, 1929				32	12	9
Expenses, Sir A. Theiler Lecture				3	3	0
Expenses, Conversazione, 1929				48	19	8
Petty Cash—						
Hon Secretary	12	0	0			
Joint Hon. Secretary	12	2	4			
Assistant Librarian	5	10	9½			
Hon. Treasurer	4	7	2½			
				36	0	4
Balance in Bank—						
Endowment	105	0	0			
Medal Fund	22	7	3			
General Fund	63	5	7			
				190	12	10
Total				£526	12	5

Examined and found correct.

6th July, 1929.

R. E. GATHER
P. M. BONNERUP } Auditors.

L. J. H. TEAKLE,
Hon. Treasurer.

REPORT OF THE LIBRARIANS FOR 1928-29.

1. DONATIONS TO THE LIBRARY. -During the year the Library has been enriched by a valuable donation received from one of the Society's past Presidents, Mr. A. Gibb Maitland. The gift, amounting to over one hundred volumes, consists of long series of "Nature," "The American Journal of Science," and "The Museum's Journal."

A member of the Royal Astronomical Society, Miss Foy, being prepared to donate the monthly notices to some overseas body, it was arranged that this Society should be the recipient.

2. EXCHANGE LIST. The following four names were added to the Exchange List during the year:—

The Division of Botany, Union of South Africa, Pretoria.

The Royal Museum of Natural History, Brussels.

The Royal Society of Edinburgh.

L'Institut des Recherches Biologiques, Perm, Russia.

Analysis of the Exchange List.

	Scientific Societies.	Government Departments.	Universities.	Museum, Libraries, etc.	Total.
Australia	9	12	4	12	37
New Zealand ...	1	...	1	1	3
South Africa	2	1	...	2	5
India	1	2	...	1	4
Java	...	1	...	...	1
Canada	1	1	...	...	2
United Kingdom ...	5	1	1	5	12
Europe	6	1	6	10	23
U.S.A.	2	1	11	12	26
South America ...	2	2	...	...	3
	29	21	23	43	116

3. PURCHASES.—The Purchases, made on the recommendation of the Council, included Dr. Ivon's Dictionary of the Sa'a Mala Language, Vol II. of the Catalogue of Scientific Periodicals.

4. PUBLICATIONS.—Volume XIII. which was received at the close of last year and Volume XIV. have been distributed. For the first time use has been made of the International Exchange Service, which, though less speedy than the post office, carries out its work free of charge to both consignors and consignees.

5. BINDING. It will be necessary to set aside in the new year an appreciable sum for the purpose of overtaking the arrears of binding.

6. SHELVING. -Additional shelving covering the eastern side of the library room has been provided, but the greater part of this is now occupied, and at the present rate of the accessions continually arriving will be filled in the course of the next two years.

L. GLAUERT.

W. E. CAMPION.

THE ROYAL SOCIETY'S MEDALLIST, 1929.

The Royal Society's Gold Medal, instituted in 1924, is awarded, at four-yearly intervals, by the Council for distinguished work in science connected with Western Australia. The first medallist of the Society was Dr. W. J. Hancock, who, in 1925, was the recipient in recognition of his pioneer work in the application of X-rays. The Council elected as the medallist for 1929, Dr. E. S. Simpson, Government Mineralogist and Analyst for the State of Western Australia, because of his many distinguished contributions to the scientific knowledge of the mineralogy and geology of Western Australia. The presentation of the medal was made at the Conversazione of the Society, held in connection with the celebration of the centenary of this State, by His Excellency the Governor, Col. Sir William Campion, K.C.M.G., Vice-Patron of the Society.

His Excellency stated that Dr. Simpson's academic career was a particularly brilliant one. Whilst a student at the Sydney Grammar School, he was awarded the West and Grahame Gold Medals at the senior public examinations in New South Wales in 1891. At the University of Sydney he gained the Horner Exhibition and Barker Scholarship for Mathematics, the Slade prize in chemistry, the Caird scholarship in chemistry and physics, and the David prize in geology. He completed the B.E. Degree in mining and metallurgy, with honours, in 1895. Subsequently he became one of the first students of the Western Australian University and obtained the degree of B.Sc. (with honours), in 1914, and that of D.Sc. in 1919.

After completing his degree at Sydney University, he was appointed Research Chemist to investigate the chemistry of the Russell silver process in operation at the Rivertree silver mill, New South Wales. From there he proceeded to Mount Morgan, Queensland, as Assayer and Chemist. In 1897, at the age of 22 he came to Western Australia as Mineralogist and Assayer to the Geological Survey Department; in this position he acted as Chief Chemist to the Mines Department and, in 1922, was appointed Government Mineralogist and Analyst, having control of the combined Health, Agricultural and Mines Laboratories.

It should be noted that between 1899 and 1905 he took an active official part in the establishment of the Kalgoorlie School of Mines. In 1927 he was appointed a Government representative of the State Committee of the Council for Scientific and Industrial Research, and from 1921 to 1926 was a member of the Senate of the University of Western Australia. During the war period he was a member of the State Munitions Committee, and technical adviser to the Perth Shell Factory.

During this busy life as an official of the State Government, he found time to make contributions to the study of the constitution and origin of several of the more complex silicates and rarer mineral groups, of which we now know, as a result of Dr. Simpson's researches, that there are very

many representatives in this State, e.g., the radio-active and the tantalum and beryllium-bearing minerals. Finding his work hampered by the lack of any accurate methods for the determination of tantalum and niobium, he devised one which is the standard commercial method to this day. But Dr. Simpson's work was by not means confined to the rare minerals. The title of the Doctor's thesis was "The Minerals of Western Australia," and that thesis is Part I. of a monograph describing all the known minerals of Western Australia, which he still has in hand and which, when published, will be the authoritative work on the subject, and will be found to consist largely of Dr. Simpson's own investigations, and to include several minerals new to science. Although this work is unpublished as yet, portions of it have been used in official reports, as well as in about 100 papers contributed to various British, Australian and American scientific journals.

The worth of this published work has been recognised by various learned societies, so that we find Dr. Simpson is a life Fellow of the Chemical Society, a Fellow of the Australian Chemical Institute (of the State Committee of which he was the first President, and twice subsequently filled the chair), a Fellow of the Mineralogical Society of America, a Member of the Mineralogical Society of Great Britain and Ireland, a Member of the Société Francaise de Mineralogie, and a Member of the Australian National Research Council. He is also Chairman of the Australian Committee for Ceramic Products in the International Union of Pure and Applied Chemistry.

Dr. Simpson has always taken an active interest in local societies devoted to the promotion of science. He was one of the founders of the West Australian Natural History and Science Society, and of the Royal Society which grew out of it, and he occupied at different times the position of President of both of these societies, as well as of the Chemical Society of Western Australia.

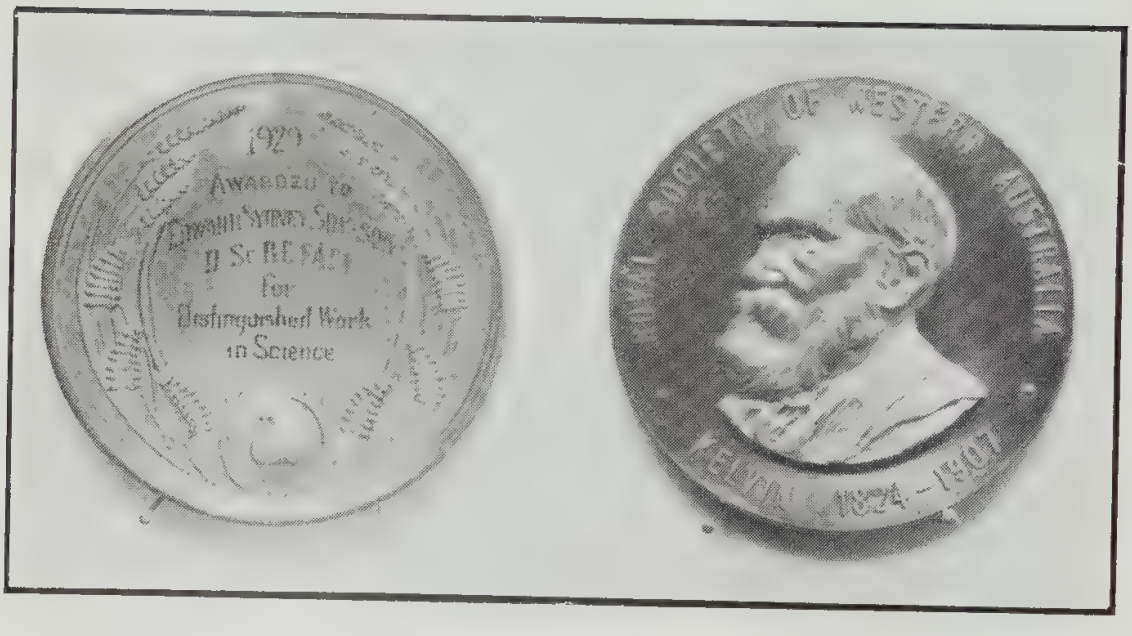
Dr. Simpson has also made unobtrusive and yet fundamental contributions to the knowledge of the rocks which carry our chief gold deposits. It is impossible without some technical details to describe the nature of this part of his work, but there is no doubt that it was the pioneering work of Dr. Simpson in this matter which laid the foundation of our present knowledge of the highly metasomatised rocks of the Golden Mile and other similar districts, knowledge which is of the utmost scientific and industrial importance. The words "industrial importance" call to mind that Dr. Simpson's extensive ceramic researches have borne abundant fruit to the State by the establishment of factories making drain pipes, roofing tiles and white ware.

It is interesting to attempt to analyse the character of one amongst ourselves who has achieved so much in a highly specialised type of work. Those who know him best in his working hours, are greatly impressed by his power of concentration on the matter in hand to the absolute exclusion of all else. This gift combined with his great intellectual powers are perhaps mainly responsible for his success and usefulness. At the same time his wide knowledge and experience have always been placed freely at the disposal of other workers in science. Another of his most valuable attributes is the power to recognise the value of scientific methods of investigation into all sorts of industrial processes, with the object of saving time and material. It is very appropriate, therefore, that the medal which he is to receive bears the head of Kelvin, who was famous, amongst other things, for the industrial application of scientific discoveries.

THE ROYAL SOCIETY MEDALLIST: 1929.

Edward Sydney Simpson, D.Sc., B.E., F.A.I.C., Government Mineralogist and Analyst.

THE ROYAL SOCIETY MEDAL.



List of Awards.

1924.—W. J. HANCOCK, D.Sc., M.I.C.E., M.I.E.E.

1929.—E. S. SIMPSON, D.Sc., B.E., F.A.C.I.

REPORTS OF COMMITTEES.

I.—EXCURSIONS COMMITTEE.

During the 1928-29 session there was a continuance of the policy restricting the number of excursions and making the object of each more definite.

The following excursions and visits were made by members of the Society:—

1. Boat Excursions. The leaders were: Mr. Glauert, Mr. Spencer Compton, and Mr. Gardner.
2. An excursion to the Forests Department's activities in the Mundaring area. Mr. W. E. Campion led the party.
3. Under the leadership of Miss E. A. Newton, a visit of inspection was made to the Dairy Products Factory of the Pascomi Co.
4. Mr. W. E. Cohen led a party of members over the Tannin Extraction Research Plant at Crawley.

The thanks of the Society are accorded to the leaders and organisers of the various outings.

WM. E. SHELTON,
Joint Hon. Secretary.

II.—THE HOUSING SCHEME COMMITTEE.

The activities of the Housing Scheme Committee continued during the first half of the 1928-29 session. Meetings with delegates of various scientific and professional societies were held and a deputation and interviews were arranged to place schemes before the Chairman of the State Centenary Committee.

During 1929, no progress was made for the following reasons:—

(a) Schemes depending on the building of University premises in some central part of the city are in abeyance owing to the time of such building being indefinite.

(b) The old Arbitration Court Buildings, considered suitable if alterations and additions could be made, were not available owing to the expense of accommodating elsewhere the present occupants of that building.

(c) The hoped for additions to the Public Library, Museum and Art Gallery do not seem to be forthcoming.

With regard to (b) and (c) no Government funds seem available for those projects, although almost to the present time it was hoped that provision would be made in Loan Estimates for additions to the Public Library, Museum and Art Gallery Buildings. At present there seems to be little prospect of securing adequate accommodation for the various scientific and other societies, for no Government funds are available and, with the possible exception of the Historical Society, the societies do not possess sufficient resources to acquire or erect a building specially adapted for scientific meetings and cognate purposes.

WM. E. SHELTON,
Joint Hon. Secretary.

III.—SALINITY IN SOILS COMMITTEE.

The appointment of the Committee arose out of a paper * read before the Society by Mr. W. E. Wood, at the November meeting, 1923, in which Mr. Wood called attention to the serious increase in salinity of natural waters following the clearing of timber from catchment areas. The task set before the Committee was to study this phenomenon further with a view to seeking for the cause or causes and means of prevention or cure.

Except in regard to the subsidiary question of the salinity of rain, which is dealt with in a separate Report presented herewith, the Committee cannot claim to have made much headway with the main problem. Nevertheless, largely as we think as the result of the discussions which took place at meetings of the Committee, the active study of this problem has been taken up with ampler resources than the Committee had at its disposal by the State Departments of Agriculture, Forests, and Railways; and good progress is being made. The Committee therefore considers that its further continuance is no longer necessary, and it asks to be demobilised.

The *personnel* of the Committee is at present: Associate-Professor E. de C. Clarke, Messrs. E. B. Curlewis, S. L. Kessell, P. V. O'Brien, and G. L. Sutton, Drs. E. S. Simpson and L. J. H. Teakle, Professor N. T. M. Wilsmore (Chairman), and W. E. Wood (Hon. Secretary).

N. T. M. WILSMORE,
Chairman.

W. E. WOOD,
Hon. Secretary.

SALINITY OF RAIN IN WESTERN AUSTRALIA.

FINAL REPORT TO THE ROYAL SOCIETY OF WESTERN AUSTRALIA.

(With Two Graphs I. and II.)

Records extending over many years have indicated that the chlorine content of rain in Western Australia is abnormally high compared with that of rain in most other countries. It seemed therefore worth while to try to investigate to what extent the salinity of soils in the State might be due to rain-borne chloride. To this end it was necessary to ascertain, if

* INCREASE OF SALT IN SOILS AND STREAMS FOLLOWING THE DESTRUCTION OF THE NATIVE VEGETATION. Jour. of the Roy. Soc., W.A., Vol. X., No. 7, pp. 35-47, Perth: 1924.

possible, whether the combined chlorine found in the rain arose from sea spray carried inland, or from dust stirred up from the soil itself, as, although the former hypothesis seemed by far the most probable, adequate proof of it was lacking.

The Committee arranged to have systematic determinations made of the chlorine content of the rain collected during the 1926 at Perth and at a number of inland stations, with a view to correlating these, if possible, with the accompanying movements of the wind between sea and land, namely towards or off the shore. Unfortunately, only the data collected at Perth are sufficiently complete for detailed study, but so far as they go they tend to support the hypothesis that the chief source of the chlorine in the rain is sea-spray carried inland. The determinations of combined chlorine (Chlorine-ion) in the rain at Perth, together with the relevant meteorological data, are summarised in the table given below. Chlorine was determined in the rain collected at Perth during 100 out of the 164 rainy days of 1926. The rainfall on most of the other 64 rainy days was small, and is not recorded here.

Column II. of the table contains the rainfall in hundredths of an inch for the 24 hours ending on the date given in Column I. Column III. contains the chlorine content in parts by weight per million parts of the rain given in column II. Column IV. contains the corresponding number of pounds weight of chlorine carried down with the rain per acre of land surface. This number is readily obtained from the data in columns II. and III. Since 1 acre = 6,273,000 sq. inches (nearly), 1 cubic foot = 1,728 cubic inches, and one cubic foot of water weighs nearly 62.3 pounds, therefore one inch of rain per acre equals:

$$6{,}273{,}000 \times 62.3 \;/\; 1{,}728 = 226{,}000 \text{ lbs. of water.}$$

Consequently one part of chlorine per million per 0.01 inch rainfall per acre equals:

$$226{,}000 \;/\; 10^8 = 0.00226 \text{ lb. chlorine per acre.}$$

or:

$$\text{Column II.} \times \text{Column III.} \times .00226 = \text{Column IV.}$$

The three columns marked "V" contain respectively the wind directions at 9 p.m. of the previous day and at 9 a.m. and 3 p.m. of the date given in column I. From these wind directions an attempt has been made to deduce roughly a "wind factor" to be applied to the total wind movement during the 24 hours. This wind factor is deduced as follows. A glance at a map shows that any wind reaching Perth from a westerly direction between NNW and SSW comes directly from the sea. To such a wind the factor 1 is given. On the other hand, any wind reaching Perth from an easterly direction between NNE and SSE may be assumed to be essentially a land wind, and to it is therefore given the factor zero. Winds coming from the

directions lying between NNW and NNE or between SSW and SSE are doubtful, as they may have derived sea-spray from eddy currents. To these winds the arbitrary factor 0.5 is given. The wind factors so deduced are given in Column VI.

Column VII. contains the total wind movement integrated over the twenty-four hours by means of the Nicholson anemometer, irrespective of wind direction. By multiplying the figures in column VII. by the corresponding wind factors we get the figures in column VIII., which may be considered to represent the net *landwards* wind movement during the twenty-four hours. The figures in column VIII. seem to be the most appropriate wind data with which to correlate the chlorine content of the rain. At the same time it must be remembered that the Nicholson anemometer does not discriminate between violent winds of short duration and steady but more moderate winds lasting for a longer time. For the same amount of total movement from the sea during the twenty-four hours, short gusty winds would certainly carry more spray than steady winds. Some of the apparent discrepancies which we find in trying to correlate salt content of rain with landwards wind movement are very probably due to this cause.

I.		II.	III.	IV.	V.			VI.	VII.	VIII.
Date.		Rainfall per 24 hours. Unit = ·01 inch.	Parts by weight of Chlorine per million parts of Rain.	Lbs. of Chlorine in Rain per Acre per 24 hours.	Direction of Wind.			Wind Factor.	Total wind movement in miles per 24 hours.	Net landwards wind movement per 24 hours.
					9 p.m.	9 a.m.	3 p.m.			
Feb.	24	27	65·0	4·00	WSW	SW	WSW	1	580	580
Mar.	10	23	3·0	·16	E	ESE	SSW	0	379	0
	11	68	11·4	1·75	SSW	SSE	SW	0·5	169	85
	27	19	3·0	·13	SW	NNE	W	1	220	220
	28	30	10·9	·74	SSW	SE	SSE	0·5	203	102
	31	40	3·5	·32	SW	ENE	WSW	0·75	192	144
April	10	16	9·9	·36	W	SSE	SSW	0·5	242	121
	15	17	2·0	·08	ENE	N	NNW	0·5	335	168
	16	92	2·0	·42	NNE	N	NNE	0·5	182	91
	17	20	3·5	·16	NE	NNE	NNW	0·5	275	138
	18	50	2·5	·28	SSW	N	WNW	1	120	120
	19	34	14·9	·38	NW	W	W	1	496	496
	20	70	17·9	2·83	SSW	W	WNW	1	368	368
	21	24	24·3	1·32	WSW	WSW	WSW	1	358	358
	22	31	27·8	1·94	WSW	SW	WSW	1	476	476
	23	12	74·4	2·02	SSW	SSW	SSW	1	614	614
	27	97	9·4	2·06	NNW	SSW	SW	1	283	283
	28	82	14·9	2·76	SSW	W	SSW	1	291	291
	29	25	40·2	2·27	SSE	SE	SSW	0	412	0
May	16	11	7·94	·20	ENE	NE	ENE	0	351	0
	17	12	7·94	·22	NE	NNE	NNW	·25	359	90
	19	43	28·27	2·75	W	SW	WSW	1	453	453
	23	62	31·25	4·37	NNW	W	W	1	287	287
	24	8	25·8	·47	W	N	NW	1	391	391
	26	71	9·92	1·59	WSW	WNW	W	1	392	392
	28	75	25·8	4·35	NNW	WSW	WSW	1	459	459
	29	77	10·9	1·90	SSE	NNE	SSW	·25	339	85
	31	42	9·42	·89	NNE	NNW	NW	·75	440	330
June	1	57	2·48	·32	W	WNW	W	1	720	720
	2	60	39·68	5·38	W	NNW	NW	1	449	449
	3	174	14·88	5·87	NW	WSW	WSW	1	566	566
	4	11	24·8	·62	SW	NE	SSE	·5	314	157
	7	28	8·93	·56	SSE	NE	SSW	·25	128	32
	9	16	14·38	·52	SSW	NE	ESE	·25	173	43
	15	103	11·41	2·66	N	DNW	NW	1	116	116
	20	74	21·33	3·35	SSW	SSE	SSW	·5	385	193
	24	21	2·48	·12	NNW	NNE	WSW	·75	319	240
	25	56	5·95	·75	WSW	N	NW	1	190	190
	26	26	2·48	·15	NNW	N	W	1	196	196

I.		II.	III.	IV.	V.			VI.	VII.	VIII.
Date.		Rainfall per 24 hours. Unit ·01 inch.	Parts by weight of Chlorine per million parts of Rain.	Lbs. of Chlorine in Rain per Acre per 24 hours.	Direction of Wind. 9 p.m.	9 a.m.	3 p.m.	Wind Factor.	Total wind movement in miles per 24 hours.	Net landwards wind movement per 24 hours.
July	1	38	6·94	·60	N	N	Calm	1	168	168
	3	46	16·86	1·76	WSW	WSW	WSW	1	501	501
	5	20	14·88	·67	WSW	ENE	NNW	·75	151	114
	6	26	4·46	·26	NNW	NNW	WSW	1	217	217
	7	13	22·82	·67	W	WNW	NW	1	334	334
	8	81	21·82	3·98	NNW	WSW	W	1	743	743
	9	55	38·19	4·75	WNW	WSW	WSW	1	714	714
	10	86	34·22	6·64	WSW	SE	SW	·75	482	362
	11	67	8·43	1·28	ESE	NNE	WSW	·5	231	116
	16	76	6·45	1·11	ENE	N	W	·25	360	90
	17	38	6·45	·56	NW	NNE	N	·5	314	157
	18	102	8·43	1·94	WNW	NW	WNW	1	538	538
	19	111	14·88	3·73	WNW	WNW	WNW	1	673	673
	20	112	17·86	4·52	WNW	WNW	WNW	1	656	656
	21	80	93·25	16·85	WNW	W	WSW	1	1,032	1,032
	22	11	63·0	1·56	WSW	SE	SSW	·5	572	286
	23	13	26·3	·77	SSE	NE	ENE	·25	151	38
	26	90	9·4	1·91	WNW	W	WNW	1	404	404
	28	18	16·37	·67	WNW	NW	WNW	1	480	480
	29	8	18·85	·34	WNW	NNW	W	1	232	232
	30	95	7·94	1·70	W	W	SW	1	459	459
	31	12	33·2	·90	SW	N	NNW	1	300	300
Aug.	1	63	10·42	1·48	SSW	ESE	WSW	·5	307	154
	3	15	35·22	1·19	SSW	NE	NW	·5	188	94
	6	36	4·96	·40	S	SSW	SSW	·5	276	138
	10	28	12·4	·78	NNW	N	WNW	1	296	296
	11	51	8·43	·96	WSW	NE	WNW	·75	169	127
	13	24	8·43	·46	WSW	W	W	1	339	339
	14	14	19·84	·63	W	WSW	WSW	1	375	375
	17	13	14·88	·44	SW	WSW	WNW	1	217	217
	18	21	5·95	·28	W	W	SSW	1	310	310
	19	29	6·94	·45	S	ENE	NNW	·5	267	134
	20	20	3·97	·18	NNE	NNW	NW	·5	180	90
	21	12	3·97	·11	NNW	NNE	NW	·75	308	231
	22	86	3·97	·77	W	NNW	WSW	1	250	250
	23	27	16·37	1·00	WSW	WNW	WSW	1	515	515
	25	15	16·37	·65	E	NNE	WNW	·25	195	49
	26	26	4·96	·29	NNE	WNW	SSW	·75	215	161
	27	47	4·96	·53	S	SSE	SSW	·5	397	199
Sept.	1	54	7·94	·97	NNW	NNW	NW	1	269	269
	3	4	19·84	·18	S	NNE	W	·5	248	124
	8	29	6·94	·45	NW	WSW	SSW	1	354	354
	14	28	11·41	·72	WNW	WSW	W	1	482	482
	21	14	8·43	·27	N	W	SSW	1	174	174
	27	6	1·98	·03	W	NNW	WSW	1	249	249
Oct.	1	77	16·37	2·84	WNW	W	WNW	1	663	663
	2	29	35·22	2·31	WNW	WNW	NW	1	628	628
	4	59	24·30	3·24	WNW	W	WSW	1	729	729
	9	29	59·52	3·89	W	W	WSW	1	727	727
	16	6	33·73	·46	WNW	W	NW	1	423	423
	19	26	17·86	1·05	WSW	W	WNW	1	508	508
	21	37	25·80	2·15	WNW	WNW	WNW	1	611	611
	22	56	23·81	3·00	WNW	NW	WNW	1	703	703
	23	19	28·27	1·21	W	W	WNW	1	685	685
Nov.	8	1	10·91	·02	WSW	WNW	WNW	1	305	305
	17	37	2·48	·21	ESE	E	ENE	0	653	0
	18	11	2·48	·06	ENE	NNE	WNW	·5	379	190
	19	23	4·96	·26	NNE	W	W	·75	320	240
	20	14	16·86	·53	W	W	W	1	443	443
	25	18	4·96	·20	NNW	N	NW	1	373	373
	27	27	7·94	·48	NNW	W	WSW	1	398	398

The data in columns III., IV., and VIII. of the table have been plotted on the accompanying graphs I. and II. The data in column VII. are also shown on the graph, but where they differ from the corresponding net or corrected data in column VIII., owing to the wind factor used being less than unity, the difference is indicated on the graph by a broken line.

Inspection of the graphs shows that, although the evidence cannot yet be claimed conclusive, the data seem to indicate a distinct correlation between the chlorine content of the rain and the landwards wind movement during or immediately preceding, the period when the rain was falling. This correlation is shown best in the months of April, July, and October, and especially during the storm of July 18th to 22nd.

A correspondence between the pounds of combined chlorine per acre of column IV. with the landwards wind movements of column VIII. is also obvious, although perhaps not quite so pronounced. This is due to the fact that the data of column IV. include the rainfall itself as a factor, whereas those in column III. do not, and correspondence between rainfall and wind movement is not necessarily close.

In addition to Perth, the chlorine content of the rain was determined at eight other stations in Western Australia, but at none of these other stations were the data collected sufficiently numerous to warrant detailed analysis. Nevertheless it seemed advisable to include them in this Report. In the following table the observing stations are arranged in alphabetical order. The rainfall is given for those days only on which the chlorine content was determined. The figures under "Rainfall' mean hundredths of an inch, and those under "Chlorine" parts by weight of combined chlorine per million parts of rain.

Date.	Rainfall.	Chlorine.	Date.	Rainfall.	Chlorine.
		CONDON.			
Jan. 9 ...	11	48·6	Mar. 9 ...	218	5·0
25 ...	30	6·0	April 21 ...	262	9·92
Feb. 9 ...	20	10·9	May 7 ...	58	4·96
		COOLGARDIE.			
Feb. 3 ...	162	9·87	May 6 ...	8	19·7
Mar. 10 ...	35	15·74	July 9 ...	30	36·2
,, 31 ...	72	4·0			
		CUE.			
Jan. 14 ...	19	15·22	May 17 ...	7	8·0
Mar. 9 ...	78	10·34	,, 20 ...	18	9·4
,, 17 ...	93	12·22	July 9 ...	35	11·28
,, 30 ...	6	10·57	,, 16 ...	38	7·05
April 15 ...	64	5·64	,, 22 ...	10	18·8
May 14 ...	22	14·57	Nov. 18 ...	17	7·28
,, 16 ...	30	8·2	,, 19 ...	104	7·05
			,, 24 ...	10	14·8
		ESPERANCE.			
Feb. 24 ...	95	22·8	May 21 ...	134	43·65
Mar. 31 ...	72	6·9	,, 29 ...	86	6·94
April 7 ...	26	5·5	July 5 ...	78	7·94
,, 23 ...	290	25·3	,, 30 ...	42	4·96
			Aug. 23 ...	66	14·38
		GERALDTON.			
April 16 ...	110	13·4	July 28 ...	17	24·9
27 ...	33	22·1	Aug. 5 ...	40	8·46
May 18 ...	40	37·13	Sept. 22 ...	50	20·41
19 ...	23	22·6	,, 27 ...	22	23·5
July 8 ...	23	35·25	Oct. 4 ...	17	66·27
9 ...	45	41·12	,, 21 ...	25	62·98
20 ...	25	74·73	Nov. 19 ...	25	39·71
26 ...	53	18·8			

Date.	Rainfall.	Chlorine.	Date.	Rainfall.	Chlorine.
		MUNDIWINDI.			
Feb. 4 ...	23	3·0	May 8 ...	36	3·47
Mar. 1 ...	11	6·0	Nov. 7 ...	22	8·93
,, 3 ...	20	5·0	,, 18 ...	45	3·47
,, 9 ...	261	2·5	,, 29 ...	15	3·47
,, 10 ...	10	3·5	Dec. 13 ...	12	3·47
April 17 ...	17	5·5	25 ...	47	6·45
		RAWLINNA.			
Mar. 11 ...	62	5·17	Nov. 20 ...	15	14·1
,, 18 ...	39	5·17			
		WILUNA.			
Mar. 11 ...	37	3·5	July 16 ...	33	2·48
May 18 ...	24	9·42	,, 19 ...	7	5·95
June 20 ...	7	3·97	Nov. 19 ...	125	3·47

Average values for the year of the chlorine content of the rain at each of the above mentioned stations are obtained by dividing the sum of the products of the above pairs of figures (namely, rainfall multiplied by the corresponding chlorine content) by the sum of the rainfall figures. The averages for the year so obtained, in parts by weight of combined chlorine (chlorine-ion) per million parts of rain are:—

Coastal Stations.	Chlorine Content.	Inland Stations.	Chlorine Content.
Condon	8·2	Coolgardie	12·0
Esperance	20·7	Cue...	9·6
Geraldton	28·7	Mundiwindi	3·5
Perth	16·5	Rawlinna	6·3
		Wiluna	4·0

In the foregoing list coastal stations are entered in the left-hand column and inland stations in the right hand column. Amongst the inland stations, the relatively high value of the chlorine content of the rain at Coolgardie is remarkable, seeing that Coolgardie is about 400 miles inland from the west coast, from which most of its rain comes.

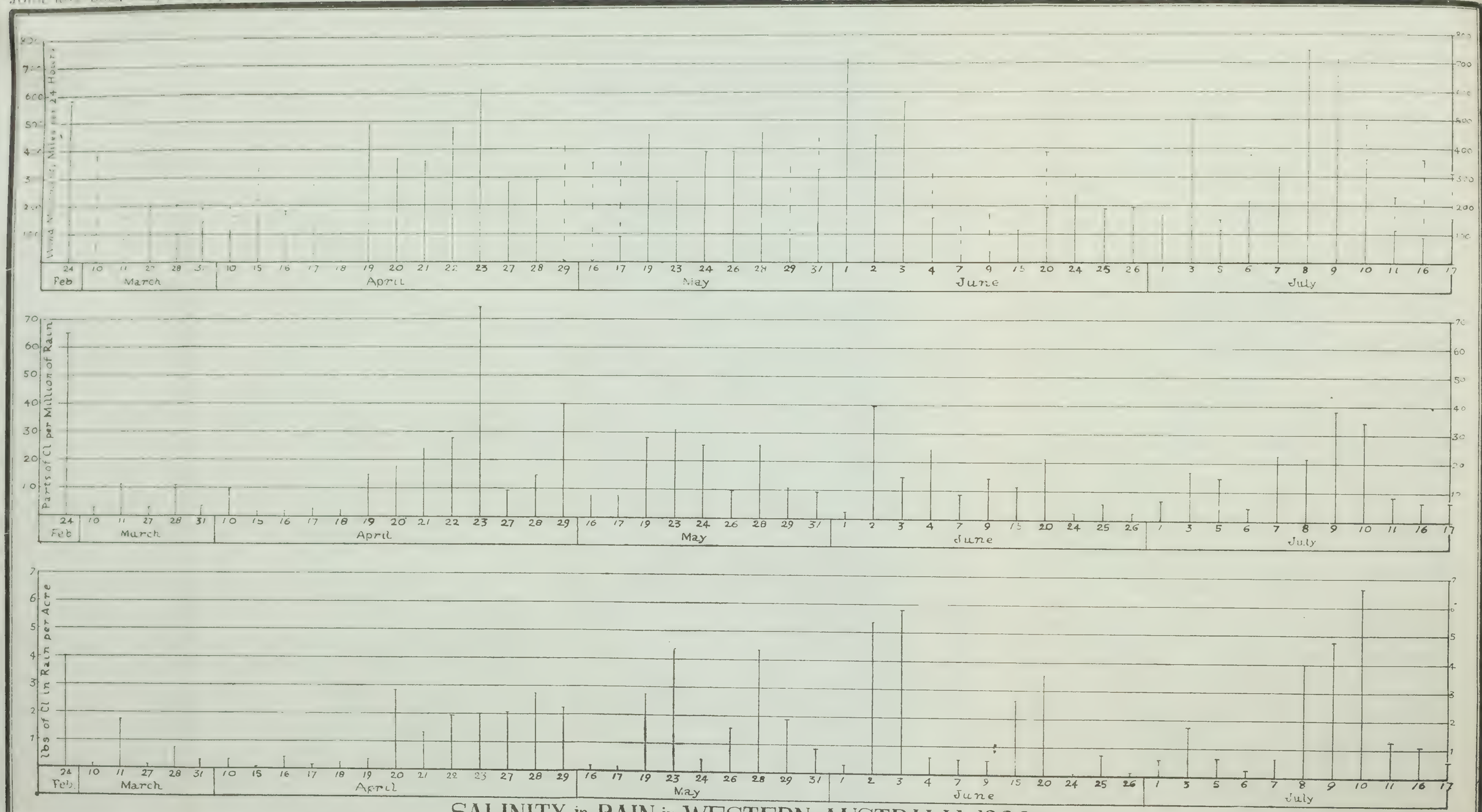
The following notes by the Hon. Secretary to the Committee on the chief storms which have occurred in and around Western Australia in 1926 contain additional evidence in support of the conclusion that the chief source of the salinity of the rain in Western Australia is wind-borne sea-spray. The figures in brackets are the "Beaufort Numbers" for wind velocity. The respective equivalents in miles per hour of the numbers used are:— (5) = 19-24, (6) = 25-31, (7) = 32-38, (8) = 39-46, (9) = 47-54, (10) = 55-63.

February.—On the 24th a storm occurred, associated with a southern "Low" whose centre was probably about latitude 40°S. Rain was chiefly coastal, extending from Esperance to a little north of Perth, but included Katanning. On the morning of the 24th fresh to strong south-westerly winds, with rough seas as far north as Geraldton.

April.—From 15 to 23rd intense and long continued southern "Low." No great wind force with it over coastal areas except on 19th and heavy gales on 22nd and 23rd. Reports of every rough weather at sea on 19th about lat. 31°S. and long. 110°E. Shipping affected all round the coast, including Fremantle. On 22nd severe gales from W to WSW as far north as Geraldton. S.S. "Pelamon" at lat. 36°S. and long. 121°E. reported barometer 29.2 in. with westerly gale and high seas (8); and S.S. "Fordsdale" at lat. 35°S. and long. 123°E. reported WNW. gale (9) with very rough seas. Weather moderated after 23rd, but from 27th to 29th another depression occurred, accompanied by general rain, although the wind did not rise above severe squalls. At sea, however, very heavy weather was reported on the 28th by S.S. "Zealandia" and S.S. "Nowshera" between Cape Leeuwin and Albany. The depression appeared to extend over a wide area, as on the 29th barometer readings of 29.03 in. were reported from south of Tasmania and New Zealand. From April 10th onwards the weather chart showed two depressions, the first being monsoonal and the second southern. From the 13th to 16th monsoonal light rains fell, extending inland from Carnarvon to Yalgoo and Cue, and south to Geraldton. On the 16th general rain commenced, extending from Fortescue to Bunbury and inland to Peak Hill, Laverton, and Kalgoorlie, but missing the southern agricultural areas. Rough westerly gales were noted on the 18th and 19th. The rainfall was due to a combination of two storms, and was mostly monsoonal, although the rough weather was chiefly from the southern storm. The rains of the 23rd and 24th were due entirely to the southern depression; very strong NW. wind off Cape Leeuwin. On the 27th S.S. "Freeburgh" and on the 28th S.S. "Talamon," about 100 and 150 miles, respectively, from Perth, reported W. winds (8) and SW. winds (7)

May.—From 16th to 19th both northern and southern storms. On 16th ENE. wind, changing about 11 a.m. on the 17th to NW. From morning of the 18th wind NNW. to SW. On 31st another depression with heavy NW. wind was reported as far north as Hamelin Pool and also across the Bight.

June.—2nd to 4th heavy winds continued, the centre of disturbance being far to the south of Australia. This could be described as a big southern storm. During the rest of June other low depressions reached the coasts of Western Australia, the centres lying far to the south. These depressions were noted chiefly off the south coasts of Tasmania and New Zealand. On the 24th fairly rough weather was noted off the west and south-west coasts.



SALINITY in RAIN in WESTERN AUSTRALIA 1926

[Facing page xxix

July.—On the 1st at lat. 38°S. and long. 106°E. the S.S. "Pakeha" reported barometer 29.48 in. and wind W (7). This depression increased slowly till the morning of the 7th, when Cape Leeuwin reported squally to moderate WNW. to W. gale, with rough seas, and barometer 29.65 in. On the 8th Cape Leeuwin reported barometer 29.35 inches, with very heavy NW. to W. wind. On the 9th Eclipse Island reported barometer 29.20 in. with very heavy weather from WNW. through W. to SW. Rough seas were reported as far north as Carnarvon. On the 10th the barometer was rising and the depression was moving eastwards with heavy to moderating SW. wind. On the 15th another southern depression was approaching Geraldton, with strong E. to NE. winds. On the 16th Cape Leeuwin reported very squally winds, and other coastal stations NW. to W. winds, with seas very rough far out. From the 17 to the 20th the depression increased, and the weather was very stormy throughout. On the 20th the wind was particularly heavy, Cape Leeuwin reporting NW. (10) with "phenomenal" seas, and barometer 20.18 in. The centre of the storm, however, was still further south. This storm lasted until the 23rd, when it passed eastwards. At Perth from the 15th to the 23rd the wind started ENE. but quickly swung to WNW., and then blew from NW. to WSW. On the 23rd the wind was from SE. to E. and NE. Gale conditions occurred on the 21st and 22nd and similar though less severe conditions on the 18th. On the 25th four ships far to the west and south-west of Perth reported barometer readings showing a deep seated depression, which reached the coast on the 28th. On the 28th the S.S. "Port Brisbane" at lat. 48°S. and long. 95°E. reported barometer 29.15 in. but wind of no great force. Rough weather lasted until the end of the month, but moderated on August 2nd. From the 26th to the 31st a deep-seated southern depression was reported, which curved round south of the Cocos Islands.

August.—From the 17th to the 23rd there was a big southern "low" of great intensity affecting the whole southern coast of Australia, and a smaller one from the 26th to the 27th.

September.—From the 1st to the 4th there was a southern storm. About the 25th a southern depression occurred with squally but not very violent winds. At the end of the month the approach of a storm was reported.

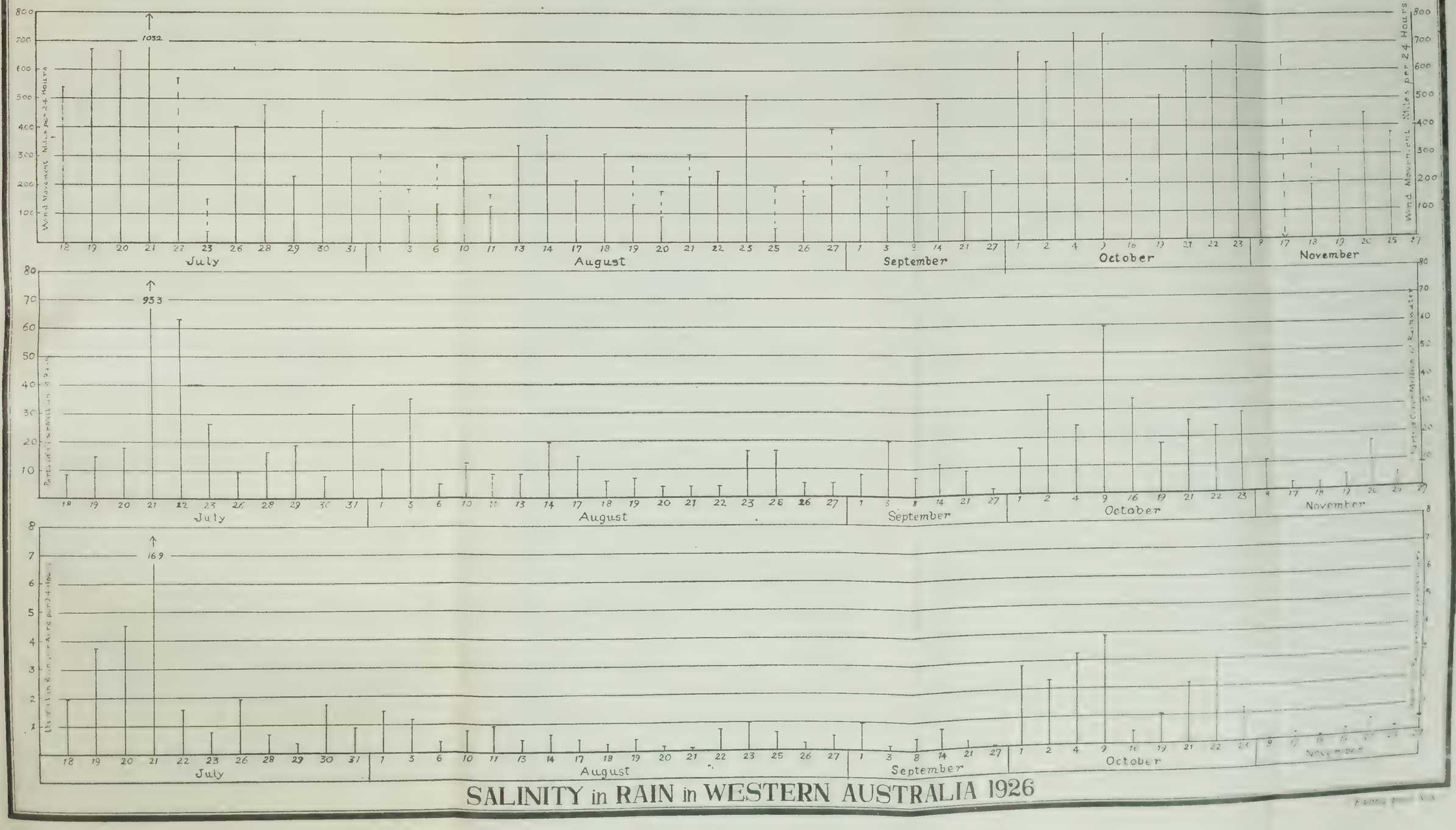
October.—On the 3rd Cape Leeuwin reported barometer 29.39 in. and very rough seas. The centre of the storm passed to the north. On the 7th the S.S. "Herminius" at lat. 39°S. and long. 93°E. reported barometer 29.06 in. and wind NNW (8); and a rapidly falling barometer was noted on the coast. The centre of the storm, however, remained far to the south, and moved quickly eastwards. Throughout Western Australia no heavy rain was reported. On the morning of the 8th Cape Leeuwin reported barometer 29.36 in with wind N. (6); and on the morning of the 9th barometer 29.62 in. and wind WSW. On the latter date S.S. "Herminius" at lat.

38°S. and long. 108°E. reported barometer 29.56 in. and wind WNW. (10). On the 10th all vessels in the Bight reported rough to high seas with squally weather from W. to WSW. From the 16th to the 24th a big southern depression passed to the south, sweeping up to Cape Leeuwin on the morning of the 18th, where barometer 29.48 in. and heavy NW. winds were reported. Rough weather occurred also off Geraldton, but rain was light and not quite general. Rough weather recurred on the 21st, accompanied by rain at Kalgoorlie and in the agricultural areas generally. On that day Cape Leeuwin reported barometer 29.30 in.; and on the 22nd 29.50 in. and NW. to W. gales were reported as far north as Geraldton, accompanied by what was described as a "good driving rain." On the 22nd Kalgoorlie reported barometer 29.81 in. with WSW. wind.

The determinations of chlorine in the rain were made by the staffs of the Government Chemical Laboratory in Perth and the Laboratory of the Western Australian Government Railways at Midland Junction. The meteorological data were supplied by Mr. E. B. Curlewis of the Commonwealth Meteorological Bureau in Perth. To all these gentlemen the Committee wishes to express its grateful thanks.

W. E. WOOD,
Hon. Secretary.

N. T. M. WILSMORE,
Chairman.



SALINITY in RAIN in WESTERN AUSTRALIA 1926

ABSTRACT OF PROCEEDINGS, 1928-29.

14th August, 1928.

Papers.—1. "Contributions to the Fauna of Rottnest of Island." (a) Vertebrates, by L. Glauert; (b) Chitons, by E. Ashby. (c) Formicidae, by J. Clark. (Communicated by L. Glauert.)

2. "A New Genus of Australian Orchids," by R. S. Rogers (Communicated by C. A. Gardner).

3. "The Male Urogenital Organs of *Tarsipes Spenserae*," by Miss D. Rotenberg.

Lecturette.—"The Value of Fossils in the Search for Minerals," by G. S. Cosby.

Exhibits.—Dr. Simpson exhibited:—

1. A small quantity of crude oil obtained with boring tools at Poole Range, Kimberley Division.
2. Specimen of Blue Asbestos from Murgina Gorge.

Mr. Glauert exhibited:—

1. The Great-Winged Shearwater, *Pterodroma macroptera,* found at Cottesloe by Miss B. Glauert. This is a first record of the bird on the west coast of the Continent.
2. A huge quartz crystal from Mt. Magnet, presented to The West Australian Museum by Mr. Jack Jones.

Mr. Wells exhibited a collection of polished chiastolites with photographs.

Mr. Steedman exhibited specimens of *Telopea speciosissima, Marianthus erubescens,* and a collection of orchids.

4th September, 1928.

Paper.—"A New Species of Termite from the Eastern Goldfields Region of W.A.," by A. G. Nicholls, B.Sc.

Lecture.—"Phosphorus Deficiency in Animals," by Sir Arnold Theiler, K.C.M.G.

9th October, 1928.

Papers.—1. "A New Anostracan from W.A.," by Miss D. Milner, B.Sc. (Communicated by Professor Nicholls.)

2. "A New Species of Stenetrium," by Professor G. E. Nicholls.

3. "Contributions to the Fauna of Rottnest Island—The description of two new species of Stenetrium," by Professor G. E. Nicholls.

Lecture—"Bitter-pit—a serious defect of Australian apples," by the President.

Exhibits.—Mr. L. Glauert exhibited a wax model of the new orchid, *Rhizanthella Gardneri,* made by Mr. Lipfert of the Museum.

Mr. Steedman exhibited a collection of native everlastings cultivated at Hamel by Mr. F. G. Berthoud.

13TH NOVEMBER, 1928.

Papers. 1. "Observations on the Load carried by the Swan River during the flood of 1926," by K. Finucane and G. Forman. (Communicated by Professor E. de C. Clarke.)

2. "Botanical Activities of Max Koch," by J. W. Audas. (Communicated by C. A. Gardner.)

3. "A New Species of Persoonia," by J. W. Audas and P. Morris. (Communicated by C. A. Gardner.)

4. "Records of Cladocera from the South-West Province of Australia, with descriptions of two new species," by D. L. Serventy.

Exhibits.—1. Fossil specimens of the stalkless crinoid, *Uintacrinus socialis*, from Kansas, U.S.A., by *L. Glauert.* Uintacrinus is confined to the Marsupites zone of the upper chalk (Santonian) and has been recorded from England generally, U.S.A. and Western Australia. In Western Australia it is known from Gingin in the south, to Dandarragan in the north.

2. A series of rock types from the Permo-Carboniferous tillite of the Irwin River Basin, by *E. de C. Clarke.* Professor Clarke is discussing the exhibits, said:- "In the basin of the Irwin River about 250 miles north of Perth occurs the southernmost exposure of a great series of marine and fresh water sediments which is found at intervals in the coastal part of the State as far north as Onslow and which occupies a wide area in the valley of the Fitzroy in the Kimberley. The marine fossils found in these beds are, some of them, the same as fossils found in beds associated with the coal seams of N.S.W. We are, therefore, justified in saying that from the geologist's point of view, they are of the same age. This age is known as Permo-Carboniferous from the fact that it is intermediate between the coal measures or Carboniferous and the Permian of Europe. Coal seams are found in the Irwin River but have not been proved farther north. One naturally thinks of coal seams as having been formed from a luxuriant tropical forest. It therefore comes as rather a shock to find unmistakable evidence that not long before the N.S.W. and Irwin River coal seams were laid down, the climate was so cold that icebergs were floating about in the sea off-shore. The evidence for this is that below the coal seams are beds consisting of boulders of varying sizes and shapes embedded in a fine grained matrix. Many of these boulders exhibit one or more perfectly flattened surfaces which are traversed in various directions by sharp scratches and grooves. There is only one agent known which produces such features, that is a glacier which drags rocks embedded in its lower surface over its rocky bed and thus flattens, polishes and striates them and the solid rock of its bed. In the Irwin River district no large surfaces of bed-rock like those at Hallett's Cove in South Australia are found, and the boulder beds are interbedded with undoubtedly water-laid deposits. It is, therefore, clear that the boulder beds are formed from the mud and stones which fell from icebergs as they slowly melted—the icebergs having been "calved" from glaciers which descended to sea level. Amongst the loose rocks left on the surface in parts of the British Isles by the great Pleistocene glaciation of the Northern Hemisphere (of much later age than our Permo-Carboniferous glaciation) are boulders of rock found 'in the solid' in Scandinavia. Hence it is inferred that the great ice sheet moved south-west from Scandinavia and overrode part of

the British Isles. If we can find among the boulders of the Irwin River tillite, some rock which is peculiar to a certain area of inland Western Australia, then we shall know where the glaciated land was. If, on the other hand, we find rocks of types unknown in Western Australia, then we must conclude that the glaciated land was not where Western Australia now is. The material for a first attempt at the solution of this interesting problem now lies before you in the form of part of a collection of fragments from the tillite boulders, made by some of the University party last August in two or three hours over two small areas taken at random in the tillite near Nangetty in the Irwin River Basin. Any of you who care to inspect the collection will see that boulders of many different kinds of rocks were huddled together in these small patches and we know from odd specimens collected on other occasions, that they by no means represent all the varieties; nor are the most interesting and uncommon rocks represented. Still, you will agree, that there is considerable range in the specimens before you. The collecting, labelling and sorting of these—the latter took Mr. Hobson and some other students two or three days—is as far as the work has progressed as yet. Microsections of many of the rocks will have to be made and examined, and then search made for similar rocks 'in the solid'. Those of you who are acquainted with Western Australian rocks will see that there are no very unusual types present, but one is struck by the variety of sedimentary rocks. A similar tillite is found in the Permo-Carboniferous rocks farther north. Of the content of the North-West tillite I know nothing. The Kimberley tillite seems to contain a much smaller variety of rocks—mainly of the type which might be expected from a land surface of Nullagine rocks."

11th December, 1928.

Paper.—"Note on the Morphology and Endothrophic Mycorrhiza of Lizanthella, *Gardneri*, and certain other W.A. Orchids."

Lecture.—"Modern Production and Marketing of Dairy Products," by Miss E. A. Newton.

Exhibits.—Mr. Steedman exhibited flowering specimens of *Cienfugosia hakaefolia*, *Poinciana*, *gilliesii*, and *Jacaranda mimosifolia*.

12th March, 1929.

Papers.—"Contributions to the Fauna of Rottnest Island." (a) Western Australian Sepiidae, by E. C. Cotton, (b) Western Australian Opiliones, by Dr. Roewer. (Communicated by L. Glauert.)

Lecture.—1. "Some Practical Consequences of Geological History," by A. Montgomery, F.G.S.

2. "The Tannin Extract Plant at Crawley," by W. E. Cohen, B.Sc.

Exhibits.—Mr. Steedman exhibited specimens of *Phaseolus caracalla* and *Eucalyptus caesia*, the latter showing considerable variation from the normal with its change of habitat from granitic country to sandplain.

9TH APRIL, 1929.

Exhibits.—1. Dr. E. S. Simpson exhibited:

(a) Quartz crystals from Sand Soak at Dajoing (80 m. east of Dalwallinu) showing two stages of growth.

(b) Pegmatite of unusual habit from the same locality.

(c) Fibrous Riebeckite or "blue asbestos" from near Mt. Margaret, Hammersley Range.

(d) Fibrous gypsum (chatoyant lustre) from the Wooramel River, near Mt. Madeline.

2. Mr. H. W. Bennetts exhibited a series of specimens which illustrated a talk on "Routine laboratory investigations of animal diseases."

3. Mr. Elliott showed apples attacked by three types of non-parasitic spot diseases:—(a) Jonathan spot, (b) bitter-pit due to premature picking, (c) cork.

4. Miss Le Souef introduced to members some live young boa constrictors, recently born or hatched at the Zoo. Their movements and general appearance were observed, and Miss Le Souef described their feeding and habits at the Zoological Gardens.

14TH MAY, 1929.

Papers.—"Contributions to the Mineralogy of W.A., Series IV.," by Dr. E. S. Simpson.

"The Water Extracts of W.A. Soils, part I.," by Dr. L. J. H. Teakle.

10TH JUNE, 1929.

Lecture.—"A Naturalist in the Murchison and Gascoyne Districts," by L. Glauert, F.G.S.

Exhibits.—Mr. Glauert exhibited a collection of small toads not yet identified.

Mr. H. G. Steedman exhibited the fruit of a native W.A. cotton plant, *Cochlospermum heteronemum.*

SOME PROBLEMS

OF

THE AUSTRALIAN APPLE EXPORT INDUSTRY.

PRESIDENTIAL ADDRESS

By

W. M. CARNE, ESQ., F.L.S.

(*Delivered 9th July; Published 4th December,* 1929.)

During the course of investigations into the cause and control of bitter pit and associated diseases of apples it has become apparent that a number of other problems connected with the apple export industry remain unsolved. Some are of major importance and intimately connected with its future prosperity. These may be conveniently grouped according to their relation to (a) production, (b) quality when marketed, and (c) marketing. No real distinction can, however, be maintained as all are closely interlinked and all are ultimately related to the *raison d'être* of the industry, namely profit to the growers.

It is not proposed to deal with all the problems which have come to our notice, but rather to confine the discussion to those which seem to be of greatest importance at the present moment.

The export trade has its origin in the fact that production exceeds consumption in Australia by 1,000,000 to 3,500,000 bushels per annum. Fortunately there exists in Europe and to a lesser extent in India, Java, and other Eastern countries, a market for this surplus. On the whole this export trade has been fairly profitable in the past and has, to a large extent, prevented the undue glutting of the Australian markets. The overseas markets have also prevented any marked diminution of the area under apple trees in any State, but at the same time have not justified any great increase of plantings in recent years. The industry is practically stationary as regards area, though the greater average age of the trees and improvements in cultural methods, etc., have increased yields generally. Any marked extension of the area under trees is unlikely unless the export industry can be made more profitable. If not, we must look forward to a slow expansion keeping pace with the increase of population in Australia. The problems dealt with in this paper are all related to the possibility of making apple export more profitable and of justifying a more rapid extension of the apple-growing industry.

1. The most marked feature of apple production in Australia is the variation from year to year of the size of the crop and consequently of the exportable surplus, although the bearing area has been relatively stationary for the past ten years or more. The annual production varies from 5,000,000 to 9,000,000 bushels with an Australian consumption of 4,000,000 to 5,500,000 bushels per annum. In Queensland and New South Wales the production fails to meet the consumption, the deficiency being supplied

mainly from Victoria and Tasmania. In Victoria the production may barely meet local requirements or may yield a large surplus for interstate and overseas shipment. South Australia does not figure largely in the export trade, except in occasional years. Western Australia has nearly always a surplus ranging up to about 700,000 bushels. Tasmania alone of all the States, always produces far in excess of local requirements. In total production, Tasmania is easily first, followed by Victoria, South Australia, Western Australia, New South Wales and Queensland in that order.

The seasonal variations of the crop, as well as the relation of production to consumption in the several States, leads to a movement of fruit within Australia. Queensland and New South Wales buy apples from Tasmania and Victoria. Indeed New South Wales is the most important market for Tasmanian apples.

It is a commonplace that good apples are often hard to obtain in apple-growing centres. This is true to some extent. It does not pay to export inferior fruit. Naturally such fruit is sold locally. Tasmania differs from the other States in that its own population is too small to consume any large proportion of its second quality apples, and consequently it exports a greater percentage of "plain" grade than the other States.

The Australian apple crops have always tended to be alternately heavy and light, and this has become very marked in recent years. By some chance the heavy crops in Western Australia now coincide with the light crops of Victoria and Tasmania. In consequence there was a movement of fruit from Western Australia to the eastern mainland States in 1927 and 1929, but the reverse movements in 1926 and 1928, which were years of light crops in this State, were prevented by quarantine restrictions. Owing to the absence of Codlin Moth in this State there is a total prohibition of apples from the other States, in all of which the moth is established. The growers in Western Australia have thus been fortunate in that they have had a good local market in their years of light crops, and in their years of heavy crops reduced competition from the other States in the overseas markets and a good sale in the other mainland States for the later varieties.

Considered from the point of view of Australia as a whole, the fluctuation of the crop is very unsatisfactory. It is impossible to utilise the European market to the best advantage when continuity of supplies cannot be relied upon either in quantity or quality. In years of light crops the fruit tends to be oversized and poorer in keeping quality than in years of heavy crops. Further, it would appear, judging by prices obtained on the same markets overseas, that the relative export value of the fruit as a whole from the several States is in the following descending order: Western Australian, South Australian, Victorian and Tasmanian. (While in part this may be due to the necessity of Tasmania exporting a greater percentage of fruit of lower grade than the mainland States, this is not the whole explanation, particularly as regards Victoria.) Owing to the crop fluctuations in the several States it follows that the contribution of each to a season's export is also variable and that therefore the relative value of different seasons' exports from Australia also varies. Buyers certainly distinguish between the fruits of different States, but unfortunately one who has made very satisfactory purchases of, say, Western Australian fruit one season cannot rely on getting Western Australian fruit in either the same quantity or quality

in the next. If therefore, the export surplus from each State could be stabilised within relatively small limits of variation, both quantity and quality could be depended upon and the problems of marketing would be greatly simplified. The confidence of buyers would be obtained, much of the adverse criticism which recurs so unfortunately each season would be eliminated, growers would be able to organise their work more satisfactorily, and prices would be enhanced. The first problem is therefore: Is it possible, by means available to growers, and at reasonable expense, to reduce the existing alternation of heavy and light crops? It is, of course, recognised that fluctuations will occur from local seasonal causes, but, as will be shown later, the great cause of alternate heavy and light crops is largely independent of ordinary seasonal conditions. It is probably closely related to the so called carbohydrate-nitrogen ratio; but it is not proposed here to deal with the solution of the problem. That this alternation of crop can be influenced was strikingly shown during the past season. The variety Dunns (Dunn's Seedling) is notably given to alternate heavy and light crops. In this State heavy and light bearing trees could, until this year, be found in any of our orchards. During the past season practically all trees of this variety bore heavily, no matter whether they would have been normally heavy or light bearing. It remains to be seen whether the bearing habits of the trees have been permanently upset and whether all trees will start in alternate bearing from this year. The upsetting of the bearing evidently commenced in 1928 when the light crop trees had little or no fruit and the heavy crop trees had light crops in agreement with a general poor crop throughout the State.

2. The second problem is one of marketing. The export season is relatively short, and its success depends largely upon lack of competition from other sources and the distribution in time and quantity of the Australian fruit at the marketing ports. Under present conditions, the shipping arrangements of each State are entered into independently. As a consequence, it is not uncommon for Australian shipments not only to arrive on markets already well supplied, but to enter into competition with each other by arriving within a few hours at the same port. For instance, two large shipments arrived at Hamburg this year within one hour of each other at a time when this market was fully supplied with American apples. No further shipments being due for two weeks, one shipment had to be stored a week Needless to say the prices received were not satisfactory. Competition between Australian apples on weak markets due to unavoidable congestion is most undesirable.

There is no doubt that there is a distinct advantage to be gained in regulating the shipments to maintain a steady supply of Australian apples to each market in quantities determined by the probabilities of demand and competiton from other sources.. Can this be done? It is obvious that marketing will be hampered by the crop fluctuations which constitute our first problem. The problem is essentially one for those controlling the export industry, though it cannot be separated from the biological problems dealt with in this paper. There would, however, appear immediate possibilities to be obtained if those responsible in the several States could arrange for unity of action in regard to the transport and distribution of consignments. If the obvious

difficulties could be overcome, not only would the industry be in a better position to secure its requirements in refrigerated shipping space, to prevent undue competition between Australian consignments, and to better utilise available markets, but it would also be in a better position to secure accurate data as to the probabilities and extent of competition. In 1929 heavy supplies of North American apples severely affected the prices of Australian fruit in the early part of the season. Much of the Australian fruit if it had been sent later would have arrived in better condition and at a time when the competition was weakening. As regard shipping, to mention only one point, boats with a reputation for carrying fruit badly would be unable to secure loadings until such time as their refrigeration equipment had been improved.

3. The third problem is an extension of the second. It concerns the period of profitable marketing. European apple requirements during the end and early part of each year are largely supplied from North America. These supplies usually come to an end in April, but may occasionally, as in 1929, extend well into May. From mid-April to mid-June the principal supplies come from Australia and to a lesser extent from New Zealand and more recently from Chili. About mid-June local supplies of soft fruits tend to reduce the demand for apples and the market for imported fruit declines. The main Australian apple season normally extends from mid April until mid-June, but consignments arrive on the market towards the end of March and in early April and extend into July. The problem to be solved is whether the early and late shipments are justified by results. If it be impossible to market the bulk of the fruit between mid-April and mid June, should the season be extended by early shipments of more or less immature fruit or by later shipments of mature fruit. The tendency in Australia is to send fruit as early as possible, shipments usually commencing about the middle of February. To some extent this is done with the hope of meeting a strong market, but apparently the principal factor is the desire of growers and agents to commence the season early to avoid congestion of work later, irrespective of the effect on the quality of the fruit, provided it has reached export size. Such fruit, certainly in the case of the standard export varieties, is always more or less immature and invites and receives very unfavourable comments in Europe, though in years when American competition is light, it may obtain profitable prices. When competition is keen, as in 1927 and 1929, much of the fruit in the earlier shipments sells in Europe at 6s. to 10s. per bushel case. As shipping and marketing charges amount to from 5s. to 6s. per case, it will be realised that to pay for growing, picking, packing the case and delivery to wharf and to return a profit to the grower, not less than 10s. to 12s. per case must be obtained. When the fruit is shipped to Germany the costs are increased by 2s. 9d. per case duty and the price obtained must be correspondingly increased to be profitable. A proportion of the fruit is sold f.o.b. to brokers in Europe, particularly in Western Australia, where over 80 per cent. of the fruit was so sold in 1929. The price paid to the grower this year were, in many cases, in excess of the net prices received by the brokers who lost heavily on some shipments. Although the growers received a profitable return, it must be obvious that the brokers' losses will eventually be passed on to the industry. Further, the experience of the brokers will react unfavourably against a method of marketing the fruit which has been popular with growers owing to the elimination of risk.

In estimating the loss due to the marketing of immature fruit, due weight must be given to the effect on later sales of more mature fruit. Such fruit comes under the influence of suspicions justifiably resulting from experience gained in the earlier sales. These points must be considered when deciding whether early season shipments are justified. Of course, seasons vary, and it may be possible to ship prime fruit several weeks earlier in one season than another. It would appear that the right time to commence shipping will vary from season to season and should be determined by a study of (1) Australian crop prospects and probable maturity date, (2) American competition, and (3) the probable effects of European fruit supplies, especially cherries and strawberries. Both the opening date and length of season should be determined by the factors mentioned. The problem, therefore, resolves itself into the following. Are early shipments of immature fruit profitable to the industry? If it is impossible to confine the export to the main export season, should the season be extended earlier or later?

4. The fourth problem arises from the third. It is at present necessary to finalise arrangements in December for the commencement of shipping in February or March. At that time, neither the size or the relative earliness or lateness of the crop is known with any certainty. It may and does happen that refrigerated space is secured which later it proves impossible to fill, except with immature fruit, or indeed to utilise at all. This leads to fruit being shipped in a condition known to be immature, or to ships departing with loading space unoccupied. The former leads to complaints from European buyers and the latter to trouble and perhaps litigation with the shipping companies. In either case, the result is detrimental to the industry. To illustrate the effects of varying seasonal maturity, local experience may be quoted. In 1928 the first large consignment of the season was despatched on the 18th February from Fremantle. The immaturity of the fruit resulted in strong complaints from Europe. Acting on this result, the first large shipments in 1929 were delayed until the first week of March, with the result that they also arrived in poor condition, because the 1929 season was at least two or three weeks later than that of 1928. The danger of commencing the export of fruit on fixed dates rather than on dates determined each season, is obvious. The problem may now be stated *Can the probable size and relative maturity of the ensuing crop be determined not later than mid-December?*

The following observations may have a bearing on the solution of this problem. There appears to be a distinct relationship between the size of the crop and the relative date of maturity of the earlier export varieties. Attention has been paid to the maturity date of apples in this State, especially Cleopatras, during the past three seasons. The comparison has been based upon storage tests and for the last two years on the starch iodine test for maturity. In 1927 the crop in Western Australia was the largest to that date (900,000 bushels). In 1928 the crop was very light (400,000 bushels), and in 1929 it exceeded that of 1927, being 1,100,000 bushels. If 1927 be regarded as a normal year for maturity, that of 1928 was approximately one week earlier and of 1929 two weeks later. As regards size of crop, the principal factor appears to be a natural alternation of seasons of heavy growth and light crops with seasons of light growth and heavy crops. This fluctuation is influenced and to some extent masked by seasonal conditions, particularly dry summers and autumns which affect growth and

thrip attacks in the blossom period which affect setting. Dry summers in years of heavy crops apparently result in a succeeding crop below normal for the light year. Thrip attacks in years of heavy crops may only act as a natural thinning, but in years of light crops may seriously affect the yield. A study of the Western Australia apple yields since 1915 shows that the regular fluctuation has been broken twice by intermediate crops. With a bearing area in the neighbourhood of 7,700 acres, the yields in bushels have been as under:—

Heavy Crops.		Medium Crops.		Light Crops.	
1917 ..	648,000	1918 ..	500,000	1916 ..	293,000
1920 ..	630,000	1922 ..	538,000	1919 ..	345,000
1923 ..	759,000			1921 ..	401,000
1925 ..	657,000			1924 ..	517,000
1927 ..	901,000			1926 ..	524,000
1929 ..	1,100,000			1928 ..	409,000

It would appear that the normal light crop since 1920 has been in the region of 450,000 to 550,000 bushels, but that the normal heavy crop has increased from 700,000-800,000 bushels to approximately 1,000,000 bushels. The increase in maximum crop is probably to be traced to the increased age of the trees, to better management, to the replacement of orchards on unsuitable sites by others on better situations, and to the elimination of unsuitable varieties. If the crop of each period of three years commencing 1916 be averaged, it will be found that there has been an increase from an average of about 500,000 bushels to 700,000 bushels for the period 1925-1927. If this average be maintained for the period 1928-1930, then the potential crop for 1930 should be in the neighbourhood of 600,000 bushels. The effects of the exceptionally dry summer of 1928-29 will probably reduce the 1930 crop in Western Australia to 450,000 to 500,000 bushels maturing probably in time for shipment on and after the first week of March. While forecasts such as these may be of value, it is probable that a study of the trees in the field during the period following the setting of the fruit would give more dependable results and would certainly prove a useful check on forecasts.

5. The fifth problem relates to maturity of and wastage in exported apples. Evidence of immaturity and wastage in our shipments overseas is, unfortunately, plentiful. In the early part of each season complaints of immaturity and of bitter pit are frequent. Later in the season, the principal complaint is of breakdown either when the fruit is unloaded or during the following two or three weeks. Maturity and wastage are closely linked and are conveniently considered together.

Immature fruits are deficient in colour, flavour, texture and in keeping quality owing to their tendency to shrivel. They are also liable to be affected with bitter pit. Over-mature fruits are deficient in flavour and texture, and are very liable to breakdown and to bruising with an attendant increased liability to fungal rots.

IMMATURITY. From brokers' reports, it would appear that the principal condition associated with immaturity is lack of colour. Few complaints are made specifically in regard to flavour, texture or tendency to shrivel. In regard to colour, it is necessary to group apples into three classes.

1. Apples sold mainly as cookers with the skins distinctly green, such as Granny Smith and French Crab. These apples when fully ripe are yellow, but the trade demands that they shall arrive in an immature condition. In consequence, no complaints are received of immaturity in these varieties. Indeed it has been pointed out, when these varieties arrived in prime yellow condition, that the trade preferred green fruit. Fortunately these varieties are not highly susceptible to bitter pit.

2. Apples predominantly yellow when mature, Cleopatra, Dunns, Five Crown, Cox's Orange Pippin, etc., are important varieties of this type. Complaints of immaturity are made when these open up with green or greenish-yellow skins. Provided these apples are kept for a time at relatively warm temperatures, and are not unreasonably immature, they will colour up in good condition. If very immature, the fruit may shrivel before colouring. Unfortunately, apples of this type are freqently very subject to bitter pit if immature when picked.

3. Apples predominantly red when mature. It is of these, and particularly of the variety Jonathan, that the most complaints of immaturity are made. No further development of the red colour occurs after apples are picked. If picked too soon, therefore, the reds are lacking and what is present may become dull instead of clear and bright. The greens will turn to yellows on exposure to warm temperatures, but this does not compensate for the demand for red colour. In a general way the lack of red is an indication of immaturity, but not absolutely so, as the amount and intensity varies with districts and seasons and to some extent with the position of the fruit on the trees. Jonathans are subject to bitter pit, but from market reports it would appear that the absence of red colour is the more important factor in regard to the prices received.

It would seem probable that of immature fruit of the types predominantly yellow, ship storage temperatures should be sufficiently high to ensure colouring. With the red varieties, no method of storage will overcome the defects due to immaturity. With the green varieties, low carrying temperatures are desirable. Fortunately these are later varieties and are unlikely to be loaded with immature Cleopatras, Cox's, etc.

BITTER PIT. Complaints of the serious occurrence of this disease are frequent in the early part of each season, particularly in Cox's, Cleopatras, Sturmer and Ribston Pippin. It has been recently demonstrated (2) that bitter pit develops in apples of susceptible varieties picked in an immature condition. Obviously the control is to delay picking the fruit, but the application of this measure brings us back to the problem of economic desirability of exporting immature fruit. Unfortunately all varieties exported early in the season are more or less susceptible to the disease, the non-susceptible varieties maturing in general relatively late. It would appear from market reports that a limited amount of bitter pit in yellow apples like Cleopatra is less detrimental to sales than a lack of red colour in Jonathan. While there is little doubt that it would be desirable to avoid complaints of both immaturity and bitter pit by not sending fruits picked in an immature or poorly coloured condition, no definite stand can be taken on an economic basis. Late March and April prices have been superior to late June and July prices about as frequently as the contrary, and have

been determined mainly by competition from American apples and European cherries, strawberries, etc. Allowances must also be made for the variation in seasons in the several states. If, as has been suggested, early crops are short crops, it cannot, however, be argued that early shipments should be made in years of light crops. The fruit of light crops tends to be oversized, very liable to bitter pit, and of poor keeping quality. This would indicate that there is then more need of confining the export to the main European season from mid-April to mid-June than in heavy seasons. The smaller crop would also assist this concentration of the season. The better keeping qualities of heavy crops would justify an extension of the season, but it would appear desirable to the writer that the bulk of the fruit should leave Australia during March and April, and that the extension of the season should be at the latter end.

The solution of the problem, however, must be decided on the basis of competition, transport facilities, size of the export crop, and markets available.

The argument that the extension of the season is necessary on account of the difficulty of handling the export within a limited time is one which suggests the need of better organisation on the orchards and of transport facilities.

In any case, there is room for improvement in the order in which fruit is exported. It appears clear that fruit predominantly red when mature should never be exported until properly coloured. Yellow and green varieties may be exported with less danger in an immature condition. Yellow varieties like Dunns, which are not highly pit-susceptible, may be sent in a more immature condition than Cox's or Cleopatra, which are very susceptible.

BREAKDOWN. This brown collapse of the tissues approaches bitter pit in its effect on sales in Europe. It is most marked during the two to three weeks following unloading. There are several forms of breakdown, some of which require much more investigation. From reports (1) it would appear that the form occurring in our apples is mainly of the type associated with over-maturity, due to late picking or more frequently to over-long storage, especially at temperatures not sufficiently low. Cox's and Jonathans are the varieties most affected. The complaints of pit in Tasmanian Cox's and lack of colour in Western Australian Jonathans early in the season, and of breakdown in both in later shipments, indicate that their safe picking season is short. The problem may now be stated.

As wastage is due mainly to immaturity or over-maturity of the fruit when picked, what is the safe period for marketing and in what order should the export varieties be picked so as to ensure a minimum of wastage?

6. The sixth problem has relation to storage temperatures. The main export season is confined to varieties picked in February, March and April, when the temperatures, at least during the two former months, are relatively high. Fruit in a forward condition, held at these temperatures, is liable to become over-mature for export.

Between the orchard and ship's side the bulk of fruit is handled in one of the following ways:

1. Forwarded direct to wharf. The time between picking and loading into ships' holds is usually not less than one week, but may reach or even exceed two weeks.
2. Forwarded to cold stores at port and there held until removed to wharf.
3. Stored in cold store in the country close to the orchard and then forwarded to wharf.

Distances between the orchards and the wharf or cold stores at ports naturally vary, but it may be pointed out that in this State the rail distance is upwards of 200 miles to the usual ports of shipment, and even over 300 miles when fruit from Mt. Barker is shipped from Fremantle instead of from Albany as is usual.

The mean maximum shade temperature at Perth is 84.7° in February, 81.3° in March, and 76.3 in April. This is practically the same as at Fremantle, while Albany, the other port of shipment in this State, is somewhat lower. Temperatures of 90° F. are not uncommon, and it follows that much of the fruit is exposed to relatively high temperatures which must increase the rate of maturation and reduce its storage life. The temperature of the fruit may be 75°-80° F. at loading. Such fruit may or may not be loaded together with fruit which has been pre-cooled. Pre-cooled fruit may be placed in warm surroundings for periods up to several days according to the distance of the cool store from the wharf. The ships' holds may or may not have been cooled down before loading. It is not proposed here to discuss the defects of ship refrigeration, which have been ably dealt with by investigators of the Cambridge Low Temperature Research Station (5), but to point out some of the problems arising out of present conditions.

The need for pre-cooling has been frequently emphasised, and its compulsory adoption in connection with the Australian export trade has been advocated. There is little doubt that if fruit is picked when it has reached that stage of maturity (picking maturity) at which it will continue to ripen to fruit of prime eating quality in store, that a system is required which will eliminate as far as possible the danger of over-maturity. Such a condition involves pre-cooling and loading into cool holds, so that a satisfactory carrying temperature of about 34° can be reached with little delay. However, it must be realised not only that ideal ships' storage is not available, but that large quantities of more or less immature fruit are shipped. If such immature fruit is pre-cooled and carried at low temperatures, it would follow that not only would it arrive in immature condition, but also the susceptible varieties would be more or less affected with bitter pit. Under present conditions the early fruit is not pre-cooled and is placed into relatively warm holds. Such holds take upwards of three weeks, according to the varying factors of temperature at loading time, size of hold, etc., to reach a steady carrying temperature, which is usually in the neighbourhood of 40° F. Some of the fruit may never get as low as that temperature (3). It is more than probable that the defects of immaturity and bitter pit in our early cargoes would have been greater but for the relatively high temperatures at which the fruit was carried. It appears desirable that pre-cooling should be adopted later in the season and that the ideal carrying

temperatures should be lower for the mature fruit to prevent over maturity breakdown. The present mean carrying temperature is probably in the neighbourhood of 45°. Better results might be obtained with mean temperatures of, say, 55° early in the season, 45° in mid-season, and 35° in the later shipments. The problem is, of course, complicated by the fact that consignments consist of mixtures of varieties maturing at different seasons.

If, as suggested, the early fruit of each season should be carried at relatively high temperatures, this would have a marked economic effect on the adoption of pre-cooling. Pre-cooling obviously should be applied to all fruit loaded in one hold or not at all, otherwise much of the expense involved will be wasted and the objective sought only partially obtained. Its adoption would involve a large expenditure in building wharfside cool stores, and the various working, depreciation, and interest charges would have to be met by the fruit stored. If a large portion, say one-third to half, of the fruit should not be pre-cooled, it is obvious that the remaining two-thirds or half must bear the entire cost, which would have to be based upon the average quantity stored. Further, unless effective use such as the storage of oranges, stone fruits, etc., could be found for these stores during the remainder of the year, the apples would have to carry a proportionately higher percentage of the overhead charges, and existing stores would receive less use. It is a question which requires study whether or not it may be more economical to extend the present system of cold storage when desirable in country stores and port stores and to dispatch the fruit to ship's side in insulated or refrigerated trucks. Such trucks could be used for other purposes than for carrying fruit. The most obvious difficulties involved in this system are those of inspection, and of delays owing to late arrivals of boats. It would probably be necessary to have insulated sheds on the wharves into which the fruit would be unloaded. There it would be inspected and, if necessary, held.

Another problem which would have to be faced in a wharfside pre-cooling store, or in an insulated store, would be that of better equipment for the more rapid handling of the fruit. The amount of manual handling at present involved at Australian ports would appear to be not only slow and expensive, but detrimental to the fruit.

The main problems dealt with may be now summarised:—

1. Is it possible to reduce the seasonal variation of apple crops?
2. Would better financial returns be obtained from unified control of the Australian export trade?
3. If it is necessary to extend the main export season, should it be by earlier or later shipments?
4. Is it possible to forecast not later than mid-December the size of the ensuing crop and its relative date of maturity?
5. What is the best period for marketing export apples so as to ensure a minimum of wastage and to avoid complaints of immaturity? In what order should the export varieties be picked?
6. What are the best temperatures for storage of export apples, both on land and in ship's stores?

It is obvious that these problems are all interlinked and that the solution of some depends upon the solution of others. It is also clear that their solution could not fail to make the export industry more profitable, probably to an extent which would justify an increase in the planted area. Any improvement in the economic condition of one of our primary industries, particularly one not dependent on local markets, would be of great value to Australia, especially at the present moment.

In conclusion, it must be emphasised that the aim of the apple export industry is, ultimately, profit to the growers. While many or all of the subsidiary problems of the industry may be individually solved, no alteration in the handling of export fruit can be justifiably adopted unless the evidence is strong that the changes will more than pay for the cost of their adoption. On the other hand, the industry is practically stationary, unfavourable comments on the quality of our exported fruit all too common, and competitors in New Zealand and Chili are already on the market. There is need for us to take steps not only to place the industry on a more progressive footing, but also to hold and develop the market which is so essential to it.

The problems herein stated indicate lines of investigation which promise to assist the industry to this desirable end.

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JOURNAL
OF
THE ROYAL SOCIETY
OF
WESTERN AUSTRALIA.
Vol. XV.

I.—A NEW GENUS OF AUSTRALIAN ORCHID.

(With two Plates, I and II.)

by

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Communicated by C. A. Gardner.

(*Read 14th August*, 1928. *Published 17th October*, 1928.)

Rhizanthella, Rogers, n.gen.

Sepala et petala erecta, subaequilonga, in tubum fissum apice lobatum connata; sepalum dorsale cum dorso columnae et petalis plus minusve adnatum, latiusculum, concavum, apice incurvum; lateralia ad bases plus minusve connata, apicibus sinum includentibus. Petala sepalis leviter breviora et illis obtecta. Labellum ad apicem pedis columnae ungue tenui mobili affixum, conspicuum, indivisum, pro flore maximum. Columna erecta, teres, sepalis aequilonga, exalata, sepalo dorsali petalisque adnata, basi in pedem brevem producta. Anthera persistens, terminalis, biocularis, valvata, erecta, vel leviter incumbens, margine posteriore clinandrii latiuscule affixa. Clinandrium subconcavum. Pollinia 4, granulosa, viscidio minuto rostelli subsessilia. Stigma majusculum, verticale, prominens. Rostellum erectum, emarginatum, anthera multo brevius.

Herbae terrestres, saprophyticae. Inflorescentiae in rhizomate ramoso incrassato subterraneo eradicato terminales. Flores parvuli, numerosi, in capitulo sessili multibracteato conferti.

Species singula adhuc nota, Australiae occidentalis incola.

R. Gardneri, Rogers, n. spec.

Herbae parviusculae, terrestres vel fortasse subterraneae, saprophyticae. Rhizomata brevia, incrassata, eradicantia, ramosa. Inflorescentiae erectae, sessiles, solitariae, terminales. Capitula ad 5 cm. in diametro; bracteae ovatae vel oblongo-lanceolatae, majusculae, imbricatae, ad 5 cm. longae, apicibus leviter patentes, circiter 12 in meis speciminibus. Flores

numerosi, parvuli, sessiles, atropurpurei, pluro-verticillati, adversi centrum, conferti. Sepala petalaque erecta, circa 4 mm. longa, in tubum fissum apice 3-lobatum connata. Sepalum dorsale cucullatum, in dimidio inferiore cum dorso columnae petalisque adnatum, triangulari-ovatum, latiusculum, concavum, apice abrupte incurvum, apiculo brevi recurvo terminans; lateralia carnosa, dimidio inferiore connata, late triangularia, apicibus acutis brevibus sinum includentibus. Petala oblongo-falcata, acuta, membranacea, sepalis leviter breviora atque multo angustiora et illis obtecta; in dimidio inferiore sepalo dorsali galeam formantia. Labellum subrufum, ad apicem pedis columnae ungue tenui mobili affixum, conspicuum, pro flore maximum, linguiforme, apice subacuta, glandulosum, indivisum, carnosissimum, ad columnam erectum deinde recurvum; lamina longitudinaliter concava, apice ex galea paulo exserta. Columna erecta, sepalis fere aequilonga, exalata, teres, sepalo dorsali petalisque adnata, basi in pedem brevem producta. Anthera persistens, terminalis, erecta, vel leviter incumbens, emucronata, obtusuiscula, apice a latere compressa, margine posteriore clinandrii latiuscule affixa, bilocularis, valvata. Clinandrium subconcavum. Pollinia 4, granulosa, viscidio minuto rostelli subsessilia. Stigma majusculum, verticale, prominens, ovatum. Rostellum erectum, apice emarginatum, anthera multo brevius. Ovarium album, terete, gracile, ad 7 mm. longum, basibus adnatis; bractea lanceolata, ovario aequilonga vel longior.

Rather small terrestrial or possibly entirely subterranean saprophytic herbs. Rhizomes short, thickened, without roots, branching. Inflorescences erect, subsessile, solitary, terminal; those on the smaller lateral rhizomes with well developed bracteate stems. Capitula up to 5 cm. in diameter; bracts rather large, ovate or oblong-lanceolate, imbricate, up to 5 cm. long, slightly spreading at the apices, in my specimens about 12 in number. Flowers numerous, small, sessile, dark purple, crowded, facing the centre, arranged in 4 or 5 whorls. Sepals and petals erect, about 4 mm. long, connate in a split tube 3-lobed at the apex. Dorsal sepal cucullate, adnate in its lower half with the petals and back of the column, triangular-ovate, rather wide, concave, abruptly incurved at the apex, ending in a short recurved apiculum; lateral sepals very fleshy, connate in their lower half, widely triangular, their apices short acute enclosing a sinus. Petals oblong-falcate, acute, membranous, slightly shorter and much narrower than the sepals and hidden by the latter, adnate in the lower half by the posterior margins to the dorsal sepal and column, forming a galea with the former. Labellum reddish, attached to the apex of the column-foot by a delicate movable claw, linguiform, conspicuous, very large in comparison with the size of the flower, the apex subacute, glandular, undivided, very fleshy, erect against the column then recurved; lamina longitudinally concave, the tip slightly protruding from the galea. Column erect, almost equal in length to the sepals, not winged, terete, adnate to the petals and dorsal sepal, produced into a short foot at the base. Anther persistent, terminal, erect, without a point, rather obtuse, compressed laterally at the apex, rather widely attached to the posterior margin of the clinandrium, valvate, 2-celled. Clinandrium slightly concave. Pollinia 4, granular, almost sessile on the minute viscidium of the rostellum. Stigma prominent vertical, ovate, rather large. Rostellum erect, emarginate at the apex, much

shorter than the anther. Ovary white, terete, up to 7mm. long, the subtending bract lanceolate, equal to or sometimes longer than the ovary.

Western Australia. Corrigin, *John Trott*, 23.5.28; closely surrounding decayed stumps of *Melaleuca uncinata*, R.Br., on ploughed land, in symbiotic association with a fungus; Shackleton, *J. H. Plant*, June 1928. Goomalling, June 1928 (a small specimen).

These stations are situated in agricultural areas, the first two almost equidistant from the coast about 160 miles inland in an easterly direction. Shackleton is some 30 miles north of Corrigin. Goomalling lies nearer the coast and about 30 miles north of Northam. In each instance the orchid appears to have been turned up by the plough or cultivator. The first inflorescence was discovered in this way in virgin soil, the mallee and tea-tree on which had been rolled and burned this season. "Previous to rolling," says Mr. Trott, "the thicket was very dense and when burnt carried a fierce fire."

Mr. C. A. Gardner, Assistant Botanist to the Western Australian Government, to whom I am indebted for the material of this remarkable orchid and drawings of the underground plant, was kind enough to personally visit this locality and he has supplied me with the following field notes and observations:—

"The main or central rhizome is usually 12 inches deep in the soil and emits lateral spreading branches from near its base. It bears one large terminal bud, and the lateral branches have solitary terminal buds much smaller in size. These buds, which are formed about 10 inches below the surface, are well developed at this depth. The plant is without any visible roots, but the greater part of each rhizome is covered with thick-based hairs. The bud of the inflorescence was sessile at the summit of a thick rhizome in the largest plant seen. On the smaller lateral rhizomes there is a well developed stem, more or less slender and covered with scale leaves, all white and very brittle. At the base of some rhizomes there were seen some old withered ones, which would appear to indicate that the growing tubers are of annual duration. The living rhizomes are white. The inflorescence is always solitary and terminal, and it appears probable that the flowers are situated some little distance below the surface of the soil. There are two reasons for assuming this. The floral bracts are only coloured at the tips in the fresh 'flowers' and they deepen with exposure to light until quite half the bract is a purple colour. The second reason is the circumstance of the discovery. Mr. Trott, who is quite an observant man, was picking up sticks on the area on which the orchid was found about 7 days prior to the time the specimens were turned up by the cultivator. Had the bracts protruded any distance above the soil, he feels confident he would have seen them. The bracts of the first 'flower' seen (the first one I sent you) were erect, the tips slightly spreading and imbricate in a perfect cup. The country in which the orchid was seen is a common type in the wheat-growing areas of this State. The soil is a yellow sandy loam with a whitish hard subsoil of about 12 inches. This country carries dense thickets of *Eucalyptus cylindriflora*, Maiden and

Blakely, and *Melaleuca uncinata,* R.Br. The orchids were found closely surrounding the decayed stumps of the latter in all the examples observed. These stumps and roots were partially rotten through the action of a fungus, the mycelium of which formed dense masses of a violet colour and webby texture in the subsoil."

A superficial examination of the single capitulum which first reached me, suggested that it belonged to a member of the *Glomerinae*, a group of orchids chiefly restricted to the Malaysian and Papuasian areas. Further examination, however, showed that there were tribal differences, and that like so many Australian orchids, the new plant was neottious in character. In had indeed distinct affinities with the *Gastrodiinae*, a subtribe in which it is now usual to include *Gastrodia*, R. Br.; *Didymoplexis*, Griff.; *Leucolena*, Ridl.; and *Auxopus*, Schltr. The first two genera are represented in our own flora, the others are respectively endemic to the Malay Peninsula and Cameroons. Of these four, it is undoubtedly most closely related to *Gastrodia*, R.Br. From this, however, it differs in the remarkable inflorescence of numerous sessile flowers, united by their ovaries and crowded together in a bracteate capitulum; also in its unwinged column, and in its stigma which is situated on the face of the column near the apex, and not at the base as in *Gastrodia*, and likewise by its slenderly clawed, very movable and exceedingly fleshy labellum. Some of these differences appear to be of sufficient importance to warrant its exclusion from the *Gastrodiinae*.

I must therefore regard it as the type of a new sub-tribe, belonging to the *Polychondreae*, which I characterise as follows:—

Rhizanthellinae, n.subtr.

Plantae saprophyticae. Innovationes e rhizomate brevi incrassata plus minusve horizontali. Folia exarticulata vel deficientia. Inflorescentiae terminales. Flores sessiles, in capitulo bracteato conferti. Sepala et petala plus minusve connata.

This new sub-tribe should be placed next to *Gastrodiinae*, in the latest (1926) Schlechterian system.[1]

By no means the least interesting observation contained in Mr. Gardner's field notes quoted above, is that which refers to the development of a more or less leafy scape from the smaller of the lateral rhizomes. This is illustrated in Plate II., fig. D, where it will be noted that even at this early stage the shoot already bears a small capitulum at its apex. It would be interesting to know what becomes of such shoots in the life-history of the plant. May it be assumed that the stems undergo the usual rhizomal thickening and that the inflorescence reaches maturity? Or are they ancestral rudimentary structures which drop off at an early stage? In his investigation of the symbiotic relationship between *Gastrodia elata* and *Armillaria mellea*, Kusano found that only the large tubers became infected by the fungus and that they alone flowered; and further that the younger ones only continued to grow so long as they remained attached to the parent tuber.

[1] Notizblatt des Bot. Gart. u. Mus. Berlin Dahlem, Bd. IX, Nr. 88 (1926).

The material of this plant so far discovered has been more or less fragmentary or damaged. A mature capitulum for instance has not actually been seen *in situ* on the rhizome, nevertheless there appears to be sufficient evidence to warrant the belief that the plant leads a complete or almost complete subterranean existence.

The records, as shown by the material available, indicate extreme stress of environment followed by the most abject plant poverty and degradation.

(I am indebted for the execution of Plate I. to Mr. W. H. Nicholls, of Melbourne).

EXPLANATION OF PLATES.

Plate I.

A.—Capitulum from the side (less than natural size). A bract and some of the flowers in the foreground have been removed.

B.—The same from above (less than natural size). A large bract and some of the flowers have been removed.

C.—Flower from the front, showing portion of ovary below dotted line.

D.—A side view of the same.

E.—Labellum from the side.

F.—Labellum from above.

G.—Column, labellum, and ovary from the side. Perianth removed.

H.—Column from the front, showing anther and stigma. Remains of dorsal sepal in background.

Plate II.

A.—Main system, showing terminal bud and lateral branches; also hollow scar, almost basal (12 inches below surface).

B.—Young plant.

C.—Ditto, showing thick-based hairs.

D.—A slender scape, with small terminal bud, 8 inches below surface.

E.—Portion of a scape, cut off by cultivator.

F.—Young plant with distorted bud, found in contact with *Melaleuca* stump.

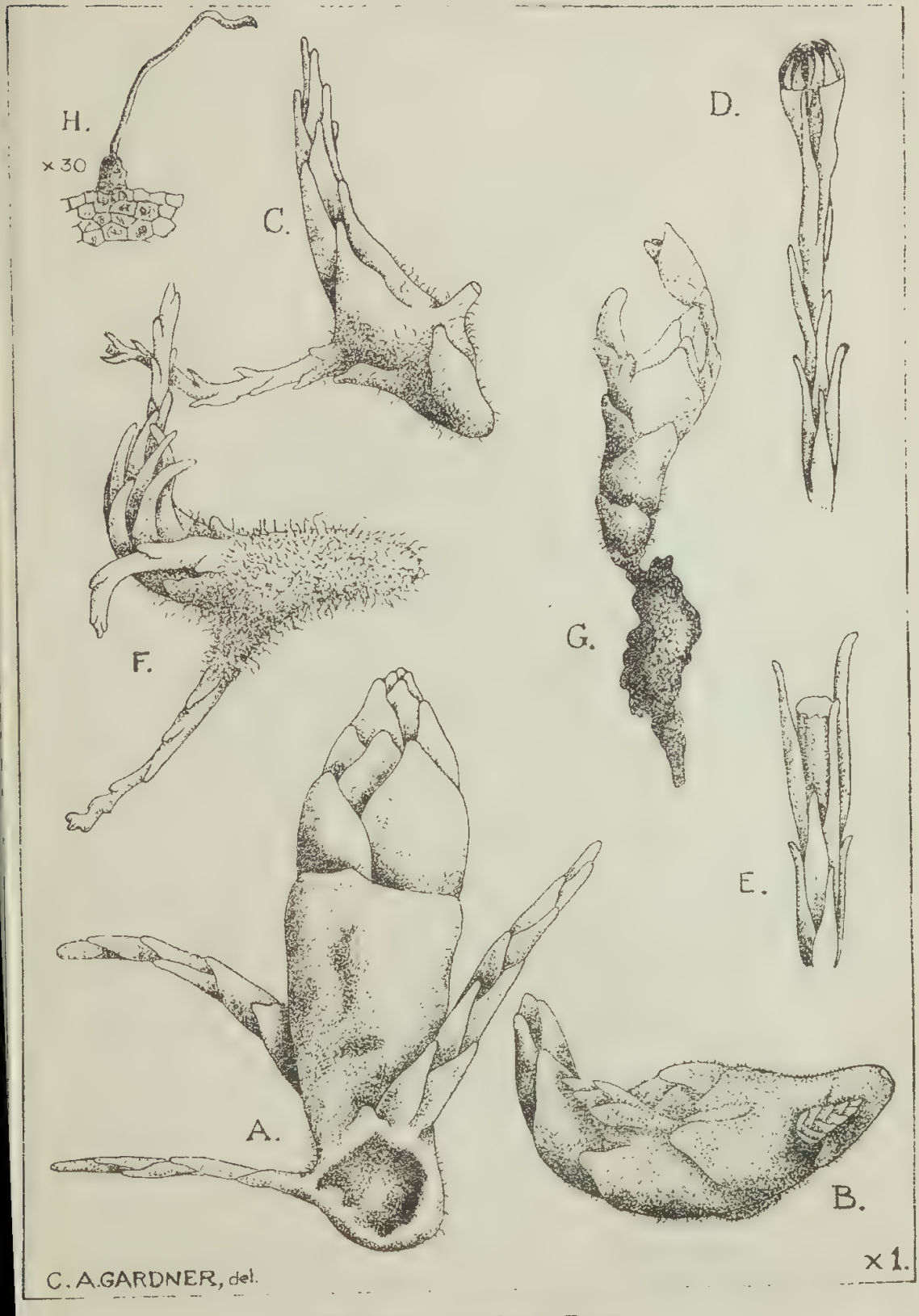
G.—Illustrating growth (the position was oblique, not perpendicular). At the base is a mummified rhizome, the middle article represents a stem with terminal bud and two lateral young rhizomes. Depth about 10 inches.

H.—A hair from the rhizome × 30. — (A — G, natural size).

PLATE I.

Rhizanthella Gardneri, Rogers.

PLATE II.



Rhizanthella Gardneri, Rogers.

By Authority: Fred. Wm. Simpson, Government Printer, Perth.

2. CONTRIBUTIONS FROM THE BIOLOGY DEPARTMENT OF THE UNIVERSITY OF WESTERN AUSTRALIA.

No. 10.

Notes on the Male Generative apparatus of Tarsipes spenserae.

(With Eight Figures, 1–8.)

By
D. Rotenberg, B.Sc.

And an Appendix by
L. Glauert, B.A.

(*Read 14th August*, 1928. *Published 27th March*, 1928.)

Owing to its primitive nature the marsupial urogenital apparatus holds a very great interest for the student of the mammalia. There exist many excellent accounts of this apparatus for certain marsupials but I can find no record of any paper on the male organs of *Tarsipes spenserae*, albeit Hill[1] has given a full description of the female genitalia of this animal.

This little West Australian marsupial, is, unfortunately, becoming extremely rare, and as I have recently had access to a small collection of these animals which included several male specimens it has seemed desirable to offer a short description of the generative apparatus, so far as I have been able to make it out from the material available.

In all, five specimens were examined but unfortunately most of these had been in spirit from 10 to 13 years. One, the only comparatively fresh specimen, was brought in as spoil by the cat some seven months ago to Mr. David Morgan, of Bornholm (Albany Denmark district), to whom I am very much indebted.

I desire also to express my thanks to Mr. Ellis Troughton through whose mediation I received a pair of Tarsipes which had been collected by Mr. Morgan and were intended for the Australian Museum, to Mr. Glauert of the Perth Museum, for a male specimen from that collection, and, in particular to Professor Nicholls who permitted me to make use of the small collection of *Tarsipes* presented by the late Mr. Hugh Leishman, of Nannup, to the W. A. University Museum, and who also offered much helpful criticism and advice during the process of the investigation.

Owing to the small size of the animal, dissection proved very difficult, even with the use of a binocular dissecting microscope, though it is very probable that had I had fresh material, I might have been able to write more positively upon certain points which must, for the present, continue to be doubtful.

As regards the external appearance there is nothing of importance to add to existing accounts of which there are already several. Gray[2], in the earliest published description of *Tarsipes* (1842), noted that the scrotum was very large which, indeed, is a fact that attracts attention even on a most superficial examination, being distinctly more than twice the size of that of a "pouched mouse" *Smithopsis murina* an animal of slightly greater dimensions than *Tarsipes* (Fig. 1). Gray, however, fails to call

(1) Description of Female U. G. organs of Tarsipes rostratus. P.L.S., N.S.W. Vol. XXV., p. 362.
(2) Ann. and Mag. N. H. Series 1, Vol. IX., p. 40.

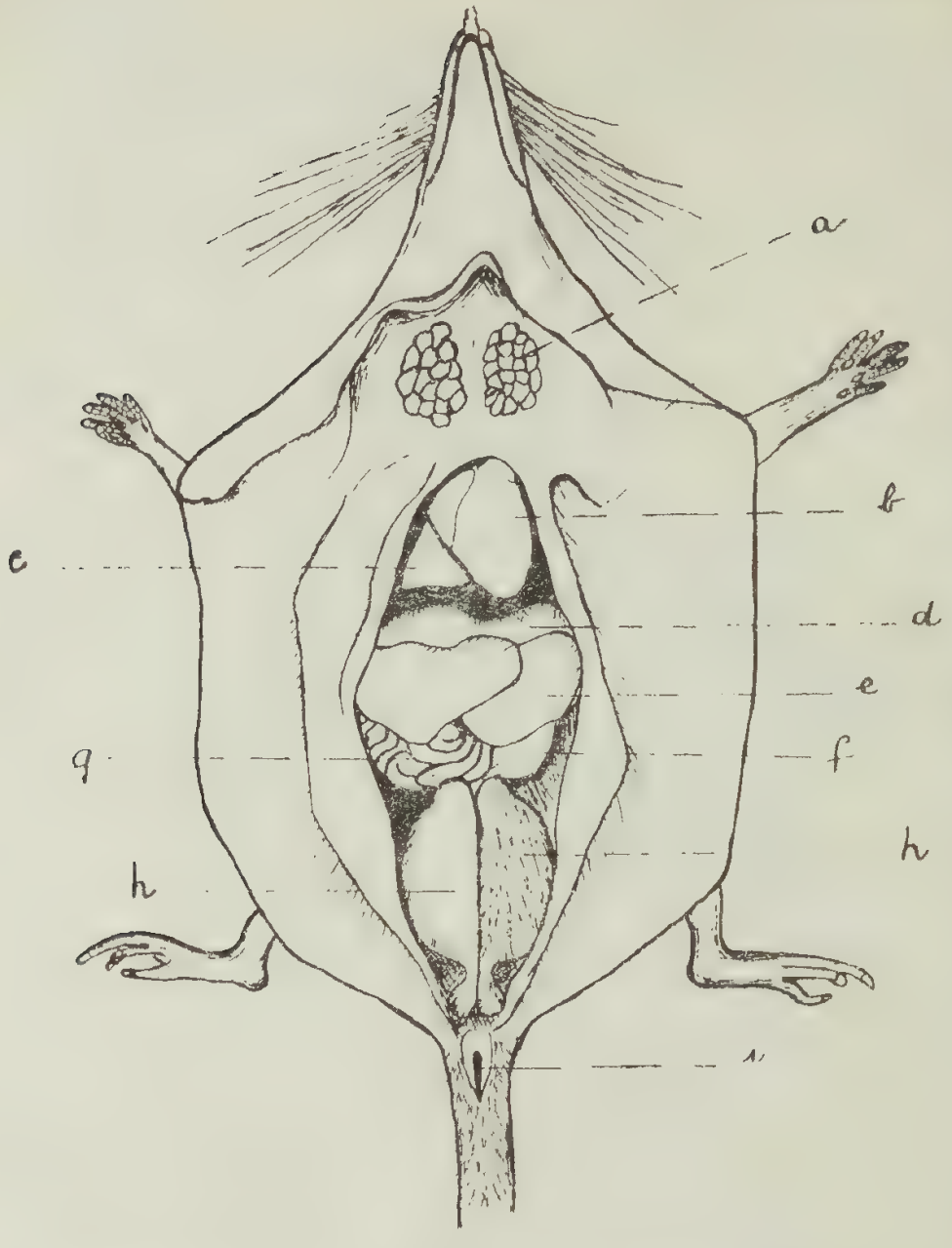


Fig. 1.

Figure 1.—Tarsipes spenseræ ♂ general dissection (× 1½).
a, Thyroid gland; b, heart; c, lung; d, diaphragm; e, liver; f, stomach; g, intestines; h, testis with scrotal sac removed; h¹, scrotal sac containing left testis; i, cloacal aperture.

attention to the unusual form of the scrotal sac which, following the contours of the testis and large associated epididymis, is produced posteriorly into a smaller pyriform sac and anteriorly into a distinct bluntly conical extension. (Fig. 1, h¹.)

DETAILED DESCRIPTION. At the outset it must be pointed out that owing to the smallness of the animal, the total length of the genitalia, measured from the anterior end of the bladder to the apex of the penis, was barely $\frac{3}{4}$in. (20 mms.).

Bladder. (Figs. 2, 3). In all of my specimens the bladder was found in the contracted condition, but even so was unusually small when compared with the surrounding structures. Writing of *Thylacinus*, Cunningham[1] says "the bladder.... ...is remarkable for its small size," but

(1) Zool. Challenger Exp., Vol. V., Part XVI., p. 164, and Plate X., Fig. 6, *b*.
(2) op. cit., Pl. X., Figs. 6 and 8.

comparatively this organ is very much smaller in *Tarsipes*. In the specimen figured, which was typical, the bladder measured 2·5 mms. in length.

In shape ovoid, its walls thick and muscular, it is completely invested by peritoneum and is connected by a distinct mesentery to the dorsal abdominal wall. There was no trace of a urachus.

At its neck, which is thinner walled, the bladder passes on to the dorsal surface of the broad anterior end of the extremely large prostate.

The mucous membrane lining the bladder was rather rugose, this rugosity disappearing in the region of the neck.

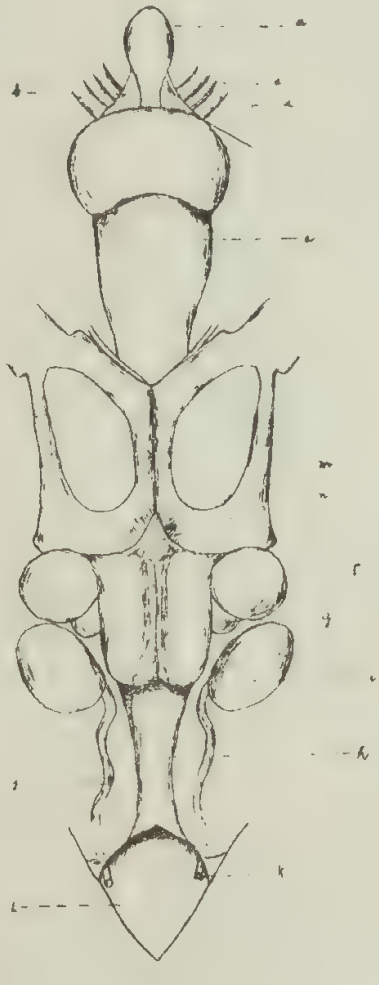


Fig. 2.

Fig. 3.

Figure 2. Tarsipes spenserae—male genitalia—ventral view (X 4).
a, bladder; b, mesentery attaching bladder to dorsal abdominal wall; c, ureter; d, vas deferens; e, prostate; f, ischio cavernosis enclosing crus penis; g, bulbus cavernosis enclosing bulb penis; h, penis enclosed in preputial fold; i, anal gland; j, duct of anal gland; and k, its aperture; m, torn muscles; n, aponeurosis formed by muscles.

Figure 3. Tarsipes spenserae—male urogenital system—dorsal view (X 4).
a, kidney; b, ureter; c, bladder; d, vas deferens; e, prostate; f, membranous urethra; g, ischio-cavernosis enclosing crus penis; h, bulbo-cavernosis enclosing bulb penis; i, penis; j, Cowper's gland; k, anal gland; and l, its duct; m, rectum.

The ureters (Fig. 3, b) enter the neck of the bladder one on each side of the mid dorsal line. Immediately posterior to these the vasa deferentia (Fig. 3, d) meet in the middle line and seem to enter the prostatic portion of the urethra in which respect they appear to differ from the condition featured by Cunningham[2] for *Thylacinus* and *Cuscus*.

Prostate and Prostatic Urethra. The prostate (Figs. 2, e; 3, e) is relatively a very large pyriform body, traversed by the urethra. It commences at the neck of the bladder by a broad base which bulges slightly and is then a little constricted. From this constriction it tapers away very gently to its posterior end upon the urethra in the region of the lowermost portion of the pubic symphysis. This division into two regions seems to correspond with an internal differentiation. The upper rounded mass appeared under the microscope to be spongy and translucent having an appearance reminiscent of a phloem sieve plate seen in surface view. The posterior, more conical portion suggests much more definitely an arrangement of closely packed test tubes seen end-on. In length it measures about 8·5 mms. while its base, or broadest part, has a diameter of about 3·5 mms.

Owing to the condition of my material the urethra, which has an extremely small and apparently uniform calibre as far as its entrance into the corpus spongiosum (measuring about ·1mms. in diameter) could be traced only imperfectly through the prostate.

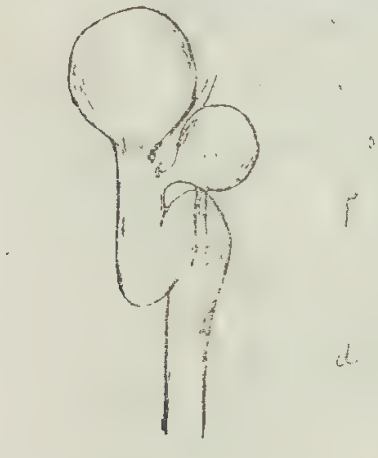


Fig. 4.

Fig. 5.

Figure 4. Lateral view of upper part of penis showing S-shaped fold (X 8). (Ischio cavernosis displaced upwardly.)

a, Ischio cavernosis enclosing crus penis; b, bulbo cavernosis enclosing bulb penis; c, folded portion of penis; d, distal portion of penis; e, ligament of levator penis (?); f, ligament of retractor penis.

Figure 5. Tarsipes spenserae—dorsal view of penis (X 4). (Cowper's glands removed, portion of ischio-cavernosis of right side removed, folded portion of penis straightened out.)

a, membranous urethra; b, crus penis; c, ischio-cavernosis; d, bulbus penis enveloped in bulbo-cavernosis; e, portion of penis formerly hidden by S shaped fold; f, apex of penis; g, preputial fold; h, ligament connecting crus penis to pelvic girdle; i, openings of Cowper's glands into urethra; j, ligament of levator penis muscle (?); k, ligament of retractor penis muscle.

On cutting it open, the prostate was found to be a little more than 1mm. in thickness at its broadest part, and apparently composed of minute tubules packed closely together like test tubes in a box, each opening independently into the membranous urethra. As mentioned above, even with the use of a binocular dissecting microscope it was only doubtfully that I could identify the openings of the ureters and vasa deferentia into the urethra and I am quite unable to say whether or no the veru-montanal eminence was present. Cunningham, likewise, in the much larger specimen of *Thylacinus*, was unable to recognise this papilla. Nor could any trace of a uterus masculinus be made out and quite probably this is lacking in *Tarsipes* as in *Thylacinus* and *Cuscus*.

Testes and Vasa Deferentia. (Figs. 6, 7, 8). The body of the testis, as before stated, is very large for so small an animal, is ovoid in shape, measuring about 12·5 mms. in length and 6·3 mms. in diameter. The epididymis (figs. 7, 8) too, is very large, abutting against the testis in such fashion as to make the conjoined structure within the tunica vaginalis

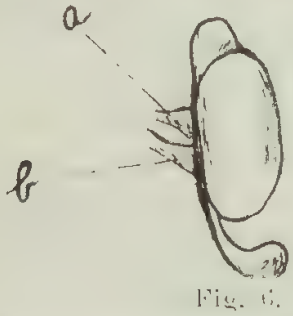


Fig. 6.

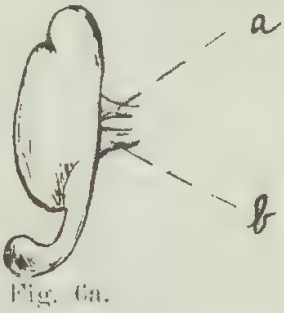


Fig. 6a.

Figure 6.—Tarsipes spenserae. Left testis removed from scrotal sac; ventral view (X $1\frac{1}{2}$).

Figure 6a.—Left testis removed from scrotal sac; dorsal view (X $1\frac{1}{2}$). a, spermatic cord; b, vas deferens.

appear quite half as large again as the actual testis (figs. 6, 6a). In addition to a well formed caput epididymis (figs. 7, a; 8, b) there is present, almost equal in size, a cauda epididymis (figs. 7, c; 8, d) which projects freely from the body of the testis into a semi-independent sac of the tunica vaginalis, and appearing from the ventral view to be an appendage of the testis. The corresponding outgrowth of the scrotal sac to contain this enlarged cauda epididymis has already been mentioned.

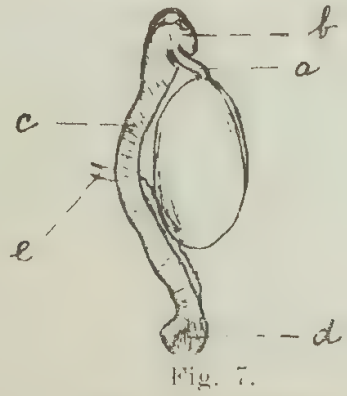


Fig. 7.

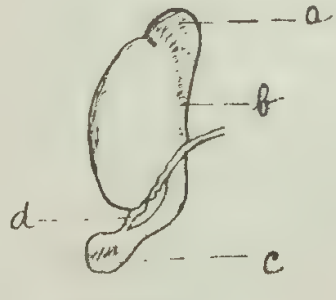


Fig. 8.

Figure 7. Tarsipes spenserae. Left testis (dorsal view) with tunica vaginalis removed, showing attached epididymis (X $1\frac{1}{2}$). a, caput epididymis; b, epididymis; c, cauda epididymis; d, vas deferens.

Figure 8.—Tarsipes spenserae. Left testis (ventral) with epididymis slightly separated from body of testis (X $1\frac{1}{2}$). a, vasa efferentia; b, caput epididymis; c, epididymis; d, cauda epididymis; e, vas deferens.

The vas deferens (figs. 2, 3, 6) is a tube of uniform thickness less than ·5mm. in diameter, and shows no related seminal vesicle. It penetrates the urethral wall close to the base of the prostate, immediately behind the point where the ureter disappears into the neck of the bladder.

Cowper's Glands. (Fig. 3, j.) A pair of these glands was present, one on either side of the middle line each with a narrow duct opening dorso-laterally into the urethra just anterior to the point where it enters the tissue of the corpus spongiosum (fig. 5). Unlike those of *Thylacinus* and of *Cuscus* as described by Cunningham these glands appear to have no muscular investment and suggest a very loose vesicular structure.

Penis. This consists as usual of three parts, viz., two corpora cavernosa and a corpus spongiosum, but there does not appear to be a distinct glans penis, the aperture suggesting that the three constituent structures are continued side by side to the apex (fig. 5). The preputial fold is attached firmly to the ventral wall of the cloaca. As in *Thylacinus* the corpora cavernosa separate widely posteriorly to form the crura (Fig. 5, b). Each crus ends in a bluntly rounded point and is enveloped in a thick layer of muscular fibres the ischio-cavernosis or erector-penis. In length it is about 2 mms. and it is firmly attached to the pelvic girdle.

As in other marsupials the bulb-penis (Figs. 3, 5) is double and each half is enclosed in a thick muscular envelope the bulbus cavernosis and is attached by a broad pedicle to the corpus spongiosum proper. The body of the penis, some little distance behind the point of junction of the crura, is bent upon itself into an S-shaped fold lying in the dorsi-ventral plane (Fig. 4). In this folded retracted condition the length of the penis, measured from the junction of the crura to its apex, was about 6·5 mms.

Muscles of Penis.- The four pairs of muscles described by Cunningham for *Thylacinus*, viz., the ischio-cavernosi (Fig. 5, c) the bulbo-cavernosi (Fig. 5, d), the retractores penis (Fig. 5, k), and the levatores penis (Figs. 5, j; 4, e), with the exception of the last named are the same for *Tarsipes*. These, however, could only be imperfectly recognised. A pair of ligaments (Fig. 4, e) attached to the lateral surface of the penis just below the bulb and possibly connected to muscles arising from the ventral surface where the two crura join, was all that could be traced.

Anal Glands. There were present only one pair of anal glands in both male and female, one on each side (Figs. 2, 3). Each was provided with a strong muscular envelope and a long duct opening independently into the cloacal chamber (Fig. 2). The glands are ovoid in shape, measuring about 1½ mms. in diameter and somewhat over 2 mms. in length.

In conclusion it is interesting to note that, in general, the genital apparatus appears to resemble that of *Thylacinus* a polyprotodont much more closely than that of *Cuscus* which belongs to the same family, viz., Phalangeridae.

(5) Attention was drawn to this appendage-like appearance in some incomplete sketches of Tarsipes by Mr. K. C. Richardson M. Sc., a former student of the University of W.A.

APPENDIX.

NOTE ON THE HABITS OF TARSIPES SPENSERAE, Gray.

By

L. Glauert, B.A., F.G.S.,

Curator of the Western Australian Museum, Perth.*

In spite of the animal's rarity, the habits of *Tarsipes spenserae* have already received considerable attention

The species was first described in 1842, and in the following January Dr. J. E. Gray published (1) a note "Habits of Tarsipes spenserae," which consisted essentially of an extract from a letter written by Mrs. Grey, the wife of Governor Grey of South Australia. According to this account an animal kept in a small cage for many months fed upon moths and flies: "Taking them by their wings, and holding them in its fore paws it ate the bodies but declined the wings themselves." The little creature was never seen to drink.

In (2), John Gould quotes from Gilbert who had a specimen alive for several months; it became quite tame, was fearless and made no attempts to escape, but being nocturnal, slept for the greater part of the day. This specimen too would eat flies, "catching them as quick as lightning and then eating them leisurely, sitting tolerably erect and holding the fly between its fore-paws." It always rejected the head, wings, and legs.

The animal was also given sopped bread made very sweet with sugar, into which it inserted its long tongue, precisely in the way in which the Honeyeaters among birds do theirs into the flower-cups for honey. A little moistened sugar on the end of the finger would attract it from one part of the cage to another. By this means an opportunity was obtained for observing the beautiful prehensile structure of the tongue, which was frequently protruded for nearly an inch beyond the nose.

Gilbert also remarked that "when sleeping the animal rests upon the lower part of the back, with its long nose bent down between its forefeet, and its tail brought over all, and turned down the back."

Mr. Neill, Deputy Assistant Commissary-General at King George's Sound also watched the animal which, he said, "is common in the district and makes its nest in the overhanging leaves of the Xanthorrhoeae and Kingias": He repeatedly dissected the little animals immediately after their capture and found in their stomachs only "a transparent fluid, like honey." He was therefore inclined to believe the natives who told him that the Noolbenger lived upon honey which it procured "by thrusting its long and slender tongue into the cups of the flowers." (3).

No fresh observations were published for many years. Oldfield Thomas, Lydekker, and others relying upon Mrs. Grey, Gilbert, or Neill for their remarks upon the animal's habits.

* Communicated by permission of the Trustees.
(1) The numbers refer to the List of References at the end of the paper

In 1921 Mr. E. le G. Troughton (4) visited Western Australia to collect for the Australian Museum, where he is the Zoologist in charge of mammals He was not able to collect specimens of the animal, but he interested a Mr. David Morgan of Tudor, in the matter and subsequently received both specimens and notes on the habits of several kept as pets in the Morgan homestead. In the main Mr. Morgan's remarks coincided with earlier observations, but I cannot agree with him, "that when sleeping the animal tucks away its tail." The ones I have had in captivity curled their tails around the body as described by Gould when quoting from Gilbert.

During the last few years I have had several chances of observing the habits of the Noolbenger, too often alas! the little creature has died in the course of a day or two, but in June, 1926, one of two specimens sent from near the King River, Albany district, survived the critical stages and lived in a roomy cage for over two months.

The cage was fitted with the branch of a tree in which was placed a cosy bird's nest to act as sleeping quarters, this course being taken because in 1920 the Museum Taxidermist, Mr. O. H. Lipfert, and Mr. F. R. Bradsaw of Tambellup, whilst collecting the Stirling Ranges had had the good fortune to find a deserted Tawny Crowned Honey Eater's nest occupied by a family of three young Noolbengers.

The animal from the King River soon became quite tame, I could handle it at will, and often placed the little animal in my waistcoat pocket when I found it numb on a cold frosty morning. At times I would moisten the tips of several fingers and dip them in sugar; the little creature would then jump onto my hand and ascend the fingers in the way it would climb a branch. Having licked off the sugar it would return to the palm and repeat the operation on the other fingers; in no single instance did it move directly from finger to finger.

Its diet consisted of sopped bread sweetened with sugar, honey diluted with water, a very occasional fly, and bush flowers. Quite a number of flowers were offered, garden flowers and wattle-blossom had no attraction, they were either cursorily examined or quite ignored, but other flowers were generally investigated, particularly Banksia cones chiefly *B. menzies*, and Dryandra, *D. floribunda*, and until I had to leave it for a day or two shortly before its death, sprays of its favourite flowers were placed in the cage every day. The animal would first lick the stamens in a most persistent manner, possibly to strip them of their pollen, and then it would force its long snout into the clusters in search of something that I could not determine, as much as an hour would be devoted to the process which was conducted on all sides of the cone and at times wonderful exhibitions were given of the creature's nimbleness and of the use made of the long powerful prehensile tail.

At times the Noolbenger would take things in its manus and then it was noticed that the first and second digits were never opposed to the rest as so persistently done by the Koala, Phascolarctus. In this connection I would mention that the local species of Ring Tailed Possum, *Pseudochirus occidentalis*, will often, and the Common Possum, *Trichosurus vulpecula*, occasionally oppose the first and second digits to the rest when holding food, whilst the Mundarda, *Dromicia concinna*, and the Noolbenger, *Tarsipes spenserae*, have never been seen to do this, though I have watched them on many occasions.

The extremities of the digits of the manus and pes are expanded, as in certain geckos, and the nails seem to be quite functionless excepting those on the syndactylous digits of the pes, which are used for combing the fur.

The first digit of the pes is nailless and opposable to the rest, the whole member forming a gripping organ as efficient as that of *Pseudochirus* or *Trichosurus*. When the animal progressed slowly along the ground, or along a branch, the two hind limbs were moved alternately but when the speed was accelerated, or the animated descended head downwards, or scuttled over the fine netting of its cage, in a succession or small leaps, the two hind limbs moved in unison.

The long, slender, tapering tail is hairy for the greater part, with the under side of the tip naked. It is an efficient organ and is used on every possible occasion, quite as frequently as in the case of *Trichosurus*. The little animal will hang by it, and if needs be, climb up itself to reach the bough from which it has been hanging in exactly the same manner as has been observed in *Pseudochirus* and *Trichosurus*. When not in use the muscles of the tail are relaxed and the organ trails behind; it is rarely curled as in *Dromicia* and *Pseudochirus*.

The distribution of the animal is more extensive than was once believed to be the case, its headquarters still seem to be the country around Albany, but it has been obtained as far north as Dandarragan near Moora, and Irwin Siding, over 200 miles north of Perth; in an easterly direction it extends to the Stirling Ranges, Gnowangerup, and Esperance.

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By Authority: Fred. Wm. Simpson, Government Printer, Perth.

3 CONTRIBUTIONS FROM THE DEPARTMENT OF BIOLOGY OF THE UNIVERSITY OF WESTERN AUSTRALIA.

No. 11.

A new species of Termite from the Eastern Goldfields Region of Western Australia.

(With one Plate III.)

By
Aubrey G. Nicholls, B.Sc.

(*Read* 14*th August*, 1928. *Published* 27*th March*, 1929.)

During the last year an investigation has been made by the author under the direction of Mr. S. L. Kessell, Conservator of Forests of Western Australia, into the relative degree of durability of various timbers, in different localities, when exposed to the attacks of termites. All of these timbers with the exception of Oregon Pine were Australian.

The scope of the investigation has included the determination of the more destructive species of termites in the different localities where the sets of timber were located, and a large number of species has been collected.

In particular some especially interesting material was secured while on a visit to Kalgoorlie, towards the end of March this year, when through the kindness of Mr. G. Brockway, Divisional Forest Officer, I was enabled to collect over a very wide stretch of country, extending Eastwards beyond Karonie, on the Trans Australian Railway, to Caluli, south west of Coolgardie.

The species with which this communication deals was taken from a spot about eight miles to the west of Kalgoorlie, in a nest inhabited by no fewer than five distinct termite species.

This particular nest stood a foot above ground level, was irregular in shape and about two feet across, with the bottom within twenty inches of the surrounding ground level, and, like many others in the immediate vicinity, gave the impression of being a mound of debris, such as might result from the incomplete burning out of an old stump, and this suggestion was at first supported by the breaking open of the mound which was composed of a quite hard material. Only when the mass had been penetrated to a depth of nearly a foot were there signs of the presence of termites.

The main mass of the termitarium was occupied by that widely distributed species, *Coptotermes lacteus*, and from the very distinctive character of the lining of the greater portion of the nest, I am convinced that this termite was the original builder and occupant. On one side of the nest, however, were chambers distinguished by a different lining material, and in this were found the other four species which were representative of the genera *Leucotermes*, *Hamitermes*, *Microtermes* and a genus new to Western Australia. *Ahamitermes*.

This latter was established by Mjöberg in 1920 from a single specimen, a soldier, likewise taken from a nest of *Coptotermes lacteus*, in North Queensland.

I was so fortunate as to obtain imagines, soldiers and workers, and am thus in a position to amplify Mjöberg's diagnosis of the genus which was, of necessity, quite incomplete.

Later, a second colony was found at Karramindie, twenty miles south of Kalgoorlie, this containing only soldiers and workers.

The new species is named *Ahamitermes hillii*, in compliment to Mr. G. F. Hill, Chief Assistant Entomologist to the Council of Scientific and Industrial Research, who has done so much work on Australasian termites, and to whom I am greatly indebted for valuable advice and criticism from time to time, as well as for generous help with both named material and literature.

I desire, also, to take this opportunity of thanking Mr. J. Clark of the National Museum of Melbourne, for similar assistance, his large collection of named material having greatly simplified my task of identifying Western Australian termites.

AHAMITERMES. Mjöberg.

Imago.—Head fairly large, rounded behind, subcircular or slightly tapering forwardly. Eyes prominent and moderately large. Clypeus prominent. Antennae 15-jointed. Pronotum slightly wider than head, about two-thirds as long as wide.

Soldier.— Mjöberg's description is as follows :—"Body small, of *Hamitermes* type ; head small, longer than broad, rounded behind ; clypeus small ; labrum long and broad, tapering to the tip, rounded ; jaws short and stout, standing apart from each other, without median tooth ; antennae very short, 12-jointed ; prothorax broad, only very slightly ridged in front With this description my specimen agrees entirely, except that the number of segments in the antennae must be stated as being from 12–15.

Ahamitermes hillii. n sp.

Imago.—Body dark brown above, lighter below; head and prothorax very dark ; antennae and maxillary palps slightly lighter ; ocelli pale ochreous. Abdominal tergites dark brown, darker along posterior borders ; ventral surface of abdomen dark ochreous with darker sternites, giving a banded appearance.

Head subtriangular, slightly wider than long, rounded behind, moderately setose ; eyes large, subcircular, prominent ; ocelli circular, approximately one-third of smaller diameter of eyes, situated just above eyes ; fontanelle oval, pointed anteriorly, situated mid-way between the eyes. Antennae 15-jointed, arising from circular cleft just in front of and close to the eyes ; 1st joint sub-rectangular, two-thirds as wide as long ; 2nd nearly square, about three-fifths as wide as first ; 3rd smallest, shorter and narrower than second, wider than long ; 4th–6th moniliform, and gradually increasing in size ; 4th wider than, and about as long as, second ; segments 3, 4, 5 and 6 more or less coalesced ; 7th-14th sub-equal, longer than 6th, with gradually increasing tendency to become pyriform ; 15th longer than

preceding one. as long as first, about as wide as second, tapering ; each provided with one or two rings of fairly long setae and fairly densely clothed with shorter ones. Clypeus large, convex, divided by median suture ; labrum broad, rounded. Prothorax large, wider than head, not quite as long, greatest width at centre of anterior half, anterior margin concave, not raised in front ; sides rounded, tapering posteriorly to narrow, slightly emarginate posterior margin ; surface sparsely setose ; margin thickly fringed with setae. Abdomen wide and depressed, gradually widening from first to eighth segment, approximately equal in length to head and thorax combined ; bluntly rounded posteriorly, moderately setose.

Measurements (in mm.)—

Length, with wings,	11·8		
without	5·95		
Abdomen, long	3·1		
Head, long	1·33	wide,	1·5
Pronotum, long	0·88	wide,	1·16
Antennae	1·54		
Eyes	2·7 x 2·4		Ocellus, 0·9
Fore wing, long	8·96	wide,	2·7
Hind wing, long	8·45	wide,	2·8

SOLDIER. -Head, pronotum, antennae and legs, straw-coloured ; jaws ferrugineous ; abdomen pale ochreous with dark intestinal contents showing through. Head subrectangular, longer than wide, broadest posteriorly, tapering slightly towards antennal clefts, broadly rounded behind, dorsal and ventral surfaces almost parallel, sparsely setose above. Antennae nearly as long as head, somewhat longer than jaws ; latter broad at base, strong, slightly arcuate at pointed tips ; teeth absent, left jaw with prominence at base. Labrum nearly half length of jaws, tapering forwardly and very slightly emarginate in front. Clypeus small, with bunch of setae. Gula very broad, two-fifths width of head, lateral edges straight ; antennae 13-jointed ; 1st large, nearly twice as long as broad ; 2nd slightly longer than broad, length approximately two-thirds width of first ; 3rd smallest, one-third length of first, two-thirds width of second ; 4th slightly wider, and half as long again as third ; 6th–12th very gradually increasing in length ; 13th longer than preceding one, tapering to obtusely pointed end. Pronotum narrower than head, anterior margin slightly raised up ; very few setae, chiefly marginal.

Measurements—

Head, with mandibles, long,	2·03
to base of labrum, long,	1·3
wide (greatest width),	0·93
at antennal clefts,	0·82
Mandibles, long, left,	0·79
right,	0·77
Antenna, long,	1·07
Pronotum, long,	0·38
wide,	0·73

Worker.—Head, thorax and legs pale straw coloured, abdomen nearly transparent with contents showing through, as a greyish mass, as in soldiers. Head longer than broad, rounded behind, bearing a fair number of symmetrically arranged setae. Antennae 13-jointed ; 1st large, about half as long again as wide ; 2nd about as long as width of first ; 3rd smallest, approximately square, about three-quarters width of second : 4th about same size as second ; segments 1–4 subrectangular, 5–13 pyriform, not showing any marked change in size with the exception of the last which is narrower and tapers to an obtuse point.

Clypeus large ; labrum broad, truncate in front.

Mandibles identical with those of Imago.

Pronotum ridged anteriorly, margin entire and fringed with setae.

Abdomen elongated, gradually tapering towards posterior end, sparsely setose.

Measurements—

Head, long,	1·25	wide,	0·8
Pronotum, long,	0·45	wide,	0·67

Locality.—Kalgoorlie and Karramindie.

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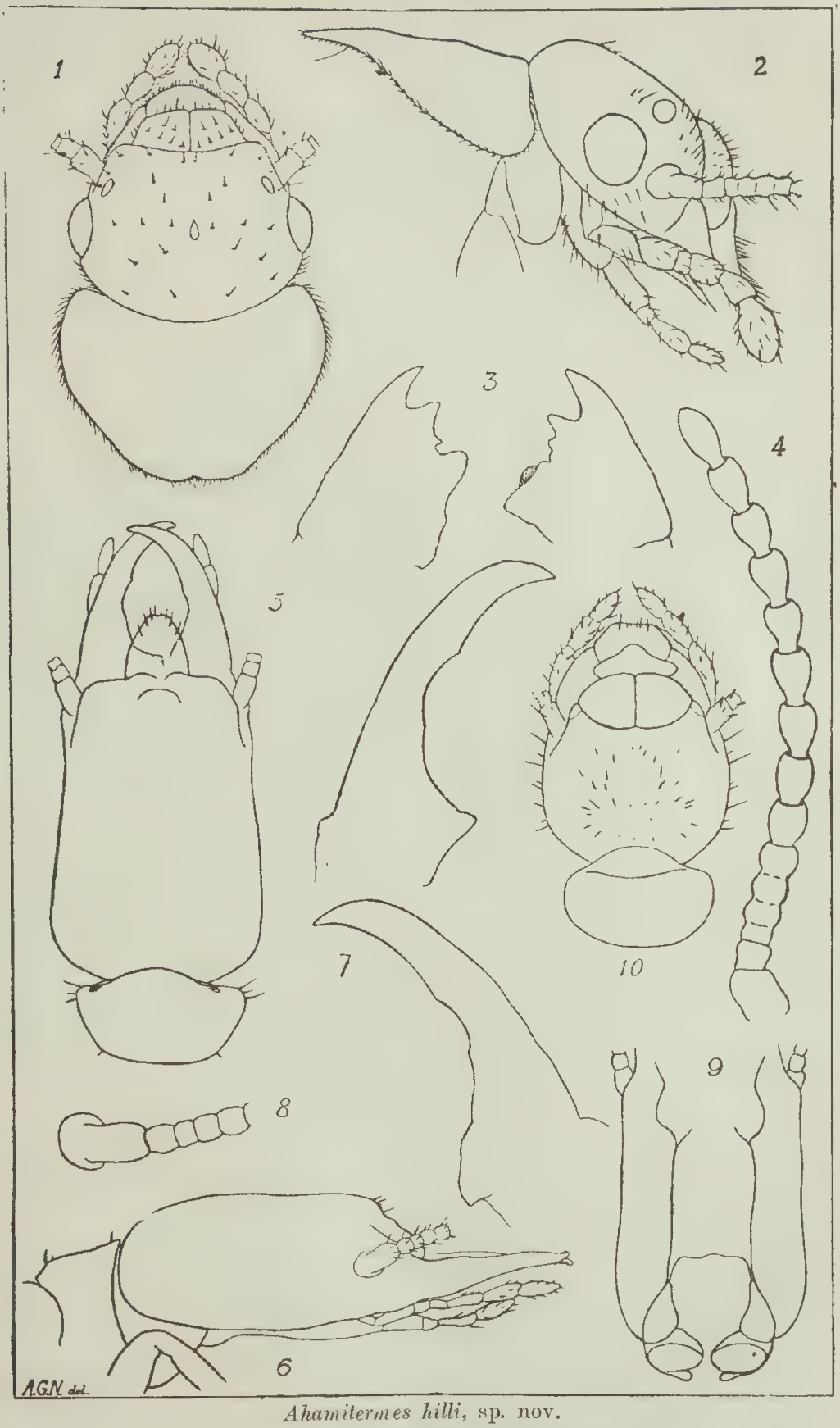
PLATE III.



Ahamitermes hilli, sp. nov.

EXPLANATION OF PLATE III.

1. Imago, head, dorsal view.
2. „ „ lateral view.
3. „ mandibles.
4. „ antenna.
5. Soldier, head, dorsal view.
6. Soldier, head, lateral view.
7. „ mandibles.
8. „ antenna, proximal portion.
9. „ gula.
10. Worker, head, dorsal view.

By Authority: FRED. WM. SIMPSON, Government Printer, Perth.

I. CONTRIBUTIONS FROM THE DEPARTMENT OF BIOLOGY OF THE UNIVERSITY OF WESTERN AUSTRALIA.

No. 12.

A description of two New Species of Anostracan Phyllopoda from Western Australia.

(With one Text Figure 9 a, b, c, and three Plates IV., V. and VI.)

By

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(*Read 9th October*, 1928. *Published 27th March*, 1929.)

As one result of a visit made by Professor G. E. Nicholls to Dalgaranga Station, Yalgoo, during the Easter vacation, 1926, a number of fresh water Phyllopods were collected. They were to be found in abundance in shallow rock pools and muddy hollows in which water had accumulated after heavy flood rains. As might be expected from an area hitherto unexplored zoologically, the collection is a valuable one and contains many interesting forms of Anostracan, Notostracan and Conchostracan Phyllopoda.

I desire to take this opportunityof expressing my thanks to Professor Nicholls, who has kindly put the collection at my disposal and has given me every assistance in facilitating their study.

Of the Anostraca on which I have commenced my investigation there are several new species, and I have no doubt that a complete examination of the entire collection will result in the discovery of further new forms.

The largest specimens of the collection, measuring little more than an inch in length, prove to be a new species of *Branchinella* (Sayce), and its most remarkable feature is the relatively enormous development of the frontal appendage. In this form, for which I propose the name *Branchinella mirabilis*, the frontal outgrowth, which is developed in the male only as an accessory clasping organ during copulation, attains a much greater size and degree of complexity than it does in any other species of *Branchinella*. In the complicated character of the frontal appendage it more nearly resembles *Chirocephalus* (Prevost) or *Dendrocephalus* (Daday), but differences in a number of important characters prevent its being assigned to either of these genera.

Closely allied to *Branchinella mirabilis* is another form which was taken from a pool some distance from the collecting ground of the first. Whilst only half the size of the former, it resembles it in general appearance, possessing, also a prominent and complicated frontal appendage which differs, however, in shape from that of *Branchinella mirabilis* and from other described species. I have named this second new species *Branchinella wellardi*, after M. G. E. P. Wellard, manager of Dalgaranga Station, and under whose guidance Professor Nicholls made his excursions.

The discovery of these two new and closely allied species from Western Australia is particularly interesting, because their nearest relative is found in a form *Branchinella frondosa** taken from near Yass, New South Wales, and

* Mr. T. Whitelegge in his list of Invertebrate Fauna (Journ. Roy. Soc. N.S.W., XXIII., 1889, p. 318) refers to three specimens of *Chirocephalus* sp. in Australian Museum collected near Yass, N.S.W. These are the specimens which have been described recently by Marguerite Henry as a new species of *Branchinella*, under the name B. *frondosa*.

recently described by Marguerite Henry. In all three forms the frontal appendage is large and divided into two main branches. Each branch is then further divided according to a plan which differs in the three species. Other representatives of *Branchinella* in W.A. in which the frontal appendage has been described are *B. eyrensis* (Sayce), *B. longirostris* (Wolf) and in these it is built on a much simpler plan, showing only the division of the appendage into two, without further branching. Whilst retaining the generic characters of *Branchinella* these new forms, together with *B. frondosa*, resemble more closely in general appearance the genus *Dendrocephalus* instituted by Daday (1910) to receive two new Phyllopods, one from Central America, and the other from the Argentine, and in the sum of their characters supply an interesting link between the two genera.

Branchinella Mirabilis, sp., nov.

(Plates IV. and V.)

Specific diagnosis.—Body stout. Trunk (including cephalon) and tail subequal. Cephalon relatively large, equal in length to first three segments of trunk, segments of trunk subequal. Tail of nine segments, terminal segment much shorter and bearing a pair of caudal rami. Prehensile antennae of male developed as strong claspers consisting of two segments, the first stout, muscular and of cylindrical form, the second shorter, chitinous, bent inwards almost to a right angle and bearing a row of small transverse chitinous ridges along the inner surface. Frontal appendage complexly branched, spinulose, united to frontal base of claspers and extending back to 4th or 5th segment of trunk.

Antennae of female flattened, tapering to a point distally and only slightly longer than antennules.

Branchial limbs.—Eleven pairs all similar and almost equal in size. 1st, 2nd and 11th pairs rather smaller than the rest. They consist of the typical parts—six endites distinctly marked off from stem and from one another: a flabellum which is articulated and very muscular; a gill or branchia and a bract or covering plate usually regarded as an exite. The flabellum increases in size from the first limb where it does not project beyond the 6th endite to the last where it is considerably longer. Branchiae, which are characteriscally bare of setae and have smooth margins, are flattened not cylindrical, and much broader than long. The 6th endite bears on its inner margin, in all appendages of the male, 7 knob-like projections which are most conspicuous in the appendages of the middle region of the body.

Caudal rami cylindrical, beset with plumose setae and approximately equal in length to the last three segments of the tail.

Penes of the male (Pl. IV., fig. 7), everted in all three male specimens collected, are sickle shaped and extend to limit of third segment of the tail. The entire surface of the organ is clothed with short recurved spines and the male aperture which is directed anteriorly is surrounded by several turnid areas surmounted with short spines

Ovisac of female (Pl IV., Figs 5a, b, c, d) is broad, pear-shaped, arising from first two segments of tail and extending, in mature forms, to limit of third segment. The aperture at distal extremity is guarded by two lips; a dorsal lip which, when closed, overlaps the ventral lip. Dorsal lip is provided on each side with two flaps, scarcely visible when aperture is closed. The ventral lip also has two distinct lateral lobes.

Eggs (Pl. IV., Fig. 6) numerous, relatively small. They are subspherical and sculptured with irregular hexagonal facets bordered by ridges.

Length :—Largest male, exclusive of Caudal rami, 29 mms.
Largest female ,, ,, ,, 26·5 mms.

Colour.—Translucent, and in life almost transparent. The lack of pigment in the body renders them invisible except for caudal rami, which are a vivid reddish orange, and the egg sac of mature female, a reddish brown colour owing to contained ripe eggs.

Locality.—Muddy pools on Dalgaranga Station, 60 70 miles North-East of Yalgoo, W. Australia.

Detailed Description.—Male and female specimens almost identical in general body form, the females only slightly smaller and differing from the males in the character of the antennae, in the presence of a median ovisac which is replaced in the male by a pair of penes, and also in the absence of any knob-like projections on the margins of the branchial limbs. In both sexes the body is elongate, compressed from side to side, and almost equally divided into anterior segment which includes the cephalon and trunk (mesasome) and a posterior segment forming the tail. The segments of the trunk bear eleven pairs of swimming appendages or branchial feet. The segments of the tail are devoid of any appendages except the last to which is articulated a pair of setose caudal rami.

Cephalon (Pl. IV., Figs. 1, 2 and 3). Large and equal in length to first three segments of trunk. It is divided by a distinct groove into an anterior part and a smaller, so called, cervical segment. The anterior part, which occupies two-thirds the extent of the cephalon, bears two large and prominent stalked eyes and a median eye or ocellus. Behind the latter is the so-called "dorsal organ" a circular patch of modified cephalic ectoderm. The cervical region of the cephalon is slightly deeper, the side walls projecting downwards on each side in form of pleura and presenting rounded margins.

Trunk (*Mesosome*) consists of eleven segments subequal in length and breadth.

Tail (*Metasome*) is formed of nine segments, the first two (genital segments) bear on the ventral surface two penes or an ovisac, the remaining seven gradually become narrower hindwards. The segments are subequal in length except the last which is much shorter, and from it extend a pair of posteriorly directed and somewhat divergent caudal rami.

Appendages.

Antennules (Pl. V., Fig. 12). These are similar structures in both sexes. They are elongate, filiform appendages, and are devoid of setae except at the tip which is provided with a tuft of sensory hairs, consisting of three long setae and a greater number of finer, olfactory setae. They present no other characteristics except a slight prominence which occurs near the middle of the appendage. In the female the antennules are almost as long as the antennae, but in the male they scarcely extend to the limit of the first joint of the claspers.

Antennae.—In the male (Pl. IV., Fig. 10).

These appendages are modified as powerful claspers, consisting of two segments, and bearing also, as an accessory copulatory structure, a well developed frontal appendage. The basil joint of the clasper is extremely large, cylindrical in shape, muscular, and with its surface bare except for

inner margin which is clothed distally with a coat of very minute hairs. The second joint is much narrower and, where it articulates is about two-thirds the width of the first joint. Distally it narrows gradually, curving inwards so as to form almost a right-angle bend and ends in a blunt point. The inner margin of the distal half of second joint is provided with a row of transverse chitinous ridges. These give the appearance in lateral view of twenty or thirty small conical chitinous teeth.

The frontal appendage (Pl. IV., Figs. 4a and 4b) is extremely large, complexly branched and covered with short stout spines. It is attached to the frontal base of the antennae and forms a squarish plate which covers the lower surface of the head. Beyond this plate it divides into two, each half exactly similar, complexly branched and studded all over with spines. The inner margin of each branch of the appendage is bare for half its length, but the distal half gives rise to five elongate, cylindrical processes unbranched, but provided with short stout spines. From the outer margin arise, at equal distances along its length, five stout cylindrical processes and each of these is irregularly pinnately branched and heavily studded with spines. These outgrowths diminish in size and complexity of branching from the first to the fifth which presents only two short branches and resembles very closely in size the corresponding branch of the inner margin of the appendage.

When not in use this appendage is coiled up and lies along the ventral surface of the body, held in position by the claspers which surround it. (Pl. IV., Fig. 2).

In the female (Pl. V., Fig. 11) the antenna is comparatively simple in structure. It is quite short, only slightly longer than the antennule, but is much broader and more leaflike, tapering to a sharp point distally. Except for a few scattered setae on the outer margin, the surface of the appendage is quite smooth.

Mouth Parts.

Labrum or upper lip (Pl. V., Fig. 13) is well developed and forms a triangular, plate the apex of which is directed backwards and overlies the mandibles. The latter (Pl. II., Fig. 14) are well developed nd are provided with a double chitinous biting edge. They are elongate structures pointed where they articulate with the cephalon and curve downwards and inwards so as to meet in the middle line at the mouth. Of the *Maxillae* only one pair is developed : the second is either lacking or not developed into a mouth appendage. They are in the form of a small triangluar plate (Pl. V. Fig. 15) with a broad setose biting edge, the setae of which are as long as the appendage itself.

Branchial Limbs (Pl. V., Figs. 8 and 9). These are all similar and differ only in size and the relative proportions of the several parts. The inner margin of the limb bears six endites or gnathobases which are abundantly supplied with plumose setae and serve to direct the food current forward to the mouth. The first and second endites are shallow leaf-like projections of the appendage, provided with very long plumose setae along their convex margins. The third, fourth and fifth endites are smaller, but subequal, and in the form of three conical outgrowths of the limb. The third endite bears two short stout unequal setae at the apex of the cone and three strong and very long plumose setae. The fourth endite agrees with the third in the disposition of setae except in possessing only two long plumose setae. The fifth agrees with the fourth but possesses only one stout spine on its apex. The sixth endite is the largest of the series and is less densely beset with setae. In both male and female this endite projects considerably beyond

the level of the other five. Its inner margin bears seven spines, conspicuous in the female but reduced in the male and obscured by seven knob-like projections which arise from the posterior surface of the endite immediately below the spines. These knobs are curved inwards and are directed forwards. They are most conspicuous in the middle region of body where they form prominent conical projections of the endite. Occurring as they do only in the male, they suggest additional copulatory structures. The posterior margin of the sixth endite is beset with short plumose, spine-like setae. The flabellum is distinctly articulated to the appendage and is well provided with muscles acting no doubt as the most important swimming organ of the appendage. It varies in size from the first, where it does not project beyond the sixth endite, to the last, where it is considerably larger. The entire margin is beset with long plumose setae. The exite forms a large ovoid covering plate or bract, the margin of which is slightly serrated. Projecting from the outer surface of the appendage, between the bract and the flabellum, is a gill or branchia. In this species it has a flattened leaf-like form, lying over the bract and rather similar to it in shape, although smaller. Its margin is smooth and devoid of setae or any indentations.

Caudal rami. These are elongate cylindrical structures, articulating with posterior segment of tail and tapering gradually to a blunt end. They are beset along their posterior and lateral margins with fine plumose setae. These appendages are apparently delicate structures, easily lost in life. Regeneration takes place readily as evidenced by the fact that, with the exception of one or two perfect specimens, all the specimens in the collection showed either one or both rami in stages of regeneration.

Specific Diagnosis. Body moderately stout, of normal form. Caudal rami, including caudal rami, about quarter longer than trunk and cephalon combined. Claspers of normal form, the second joint longer than the first and curved inwardly, making an angle of about 45°. Distal extremity straight, forming a rounded end with a sharp point on the inner margin. Entire inner surface of second joint with a row of prominent chitinous ridges, directed backwards and each one approximately hemispherical in shape.

Frontal appendage excessively branched, extending beyond the tips of the claspers and reaching to fourth or fifth segment of the trunk. Proximally, where it is attached to the head, it forms a wrinkled band or ribbon, which, when the appendage is not in use, hides the under surface of the head. Distally it expands slightly, giving off two long cylindrical, branched outgrowths which form the main part of the appendage, and then terminates suddenly, the distal border being slightly emarginated in the middle. The two outgrowths are exactly similar. From the outer margin arise nine cylindrical processes, unbranched, which decrease progressively in size from the first to the last. The inner margin bears seven similar lateral branches. All of these outgrowths are thickly set with long and short spines and in addition, the distal half of the main stem of the appendage is grooved along the under side and this is also beset with spines.

Antennae of female similar to those of *B. mirabilis*.

Branchial feet all similar. They are relatively longer and narrower than those of *B. mirabilis*. The first and second pairs are very small, the remaining nine pairs subequal. They agree with the former species in most respects, the covering plate or bract, however, not being so well developed. Branchiae are cylindrical, not leaflike, and they are much longer than they are broad, differing entirely in shape from the bract. The males of this

species, like those of *B. mirabilis*, possess knob-like projections on the sixth endite, but these are fewer in number and are lacking altogether in appendages ten and eleven and insignificant in first and second pairs. Disposition of setae on endites three, four and five, as in *B. mirabilis*.

Ovisac similar in shape to that of *B. mirabilis* but relatively longer, extending slightly beyond the fourth segment of the tail. Projecting from the ventral surface and in the middle line there is a small lip or ridge similar to that described by Sayce (1902) in *B. australiensis* and possibly of use during copulation. The opening of the ovisac is guarded by two simple lips, a dorsal and a ventral lip, and when closed the dorsal lip slightly overlaps the ventral.

Eggs are not so numerous but relatively much larger than those of *B. mirabilis*. They are similarly sculptured, and although the adults of two species differ greatly in size the eggs are scarcely distinguishable.

Penes of male when everted are long and spinulose, extending beyond the fourth segment of the abdomen. The outer surface is clothed with strong recurved spines, whilst the distal and inner surfaces possess stouter spines with swollen bases, all directed backwards.

Length.—Male and female exclusive of caudal rami 11 mms.

Locality.—Dalgaranga Station, 60-70 miles North-East of Yalgoo, Western Australia.

Affinities.—In discussing the affinities of these two new species with allied forms, an interesting feature presents itself in *B. wellardi*. In a number of specimens in the collection there is present a distinct outgrowth or lobe which arises from the inner margin of the first segment of the claspers and projects slightly at the junction of the first and second segments. (Text fig. 9a.)

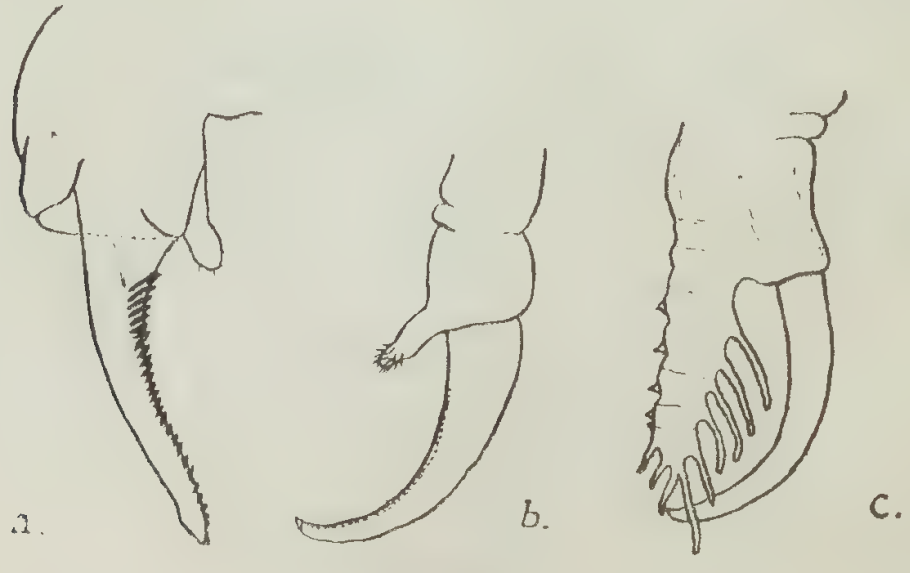

Fig. 9.

Fig. 9.—(a) Clasper of *Branchinella wellardi*, showing maximum development of accessory lobe.
(b) Clasper of *Dendrocephalus geayi*.
(c) Clasper of *Branchinellites kugenumaensis*

This outgrowth varies in size in the specimens in which it occurs and is never more than a thin membranous lobe possessing at its margin a few short setae. A similar outgrowth, although much larger and considerably lobed, is to be found in a form which Daday originally described as *Branchinella kugenumaensis* from Japan. On the discovery of a second very closely allied species from Western Africa a little later, he removed *B. kugenumaensis* from the genus *Branchinella* and instituted a new genus to receive these two species. To this genus he gave the name *Branchinellites*, which differs from *Branchinella* chiefly in the presence of a serriform lobe on the basal segment of the clasper.

The occurrence of an accessory lobe on the clasper is a common feature amongst members of the Anostraca. *Branchinella*, however, is described as lacking any accessory lobe or spur other than the frontal appendage. In *Chirocephalus* and allied genera, *viz.*, *Chirocephalopsis* and *Pristicephalus*, it is a conspicuous lobed structure. In *Dendrocephalus* it takes the form of a small digitiform process projecting from the inner angle of the clasper at the junction of the first and second joints and is thickly beset at the tip with spines or hairs. (Fig. 9b.) It is most conspicuous in *Branchinellites* (Fig. 9c) where it is considerably lobed and projects to the limit of the second segment of the clasper.

The specimens of *B. wellardi*, which possess this accessory lobe on the clasper, come very close to the genus *Branchinellites*. They may be separated from it only by the nature of the outgrowth itself, which is never more than a simple lobe, devoid of any serrations and not in any way lobed. The extreme variability of this lobe and in most specimens its absence altogether would prevent *B. wellardi* from being assigned to genus *Branchinellites*. This species may therefore be regarded as a transitional form intermediate between the two genera, *Branchinella* and *Branchinellites*.

In the complex nature of the frontal appendage the two new species resemble closely *Dendrocephalus*. They differ, however, in the character of the limbs. These are all alike in *Branchinella*, but in *Dendrocephalus* the first and second pairs in the male are notably different from the rest. With the exception of one species *B. frondosa*, *B. mirabilis* and *B. wellardi* can be readily distinguished from other described species of the genus by the complicated branching of the frontal appendage. This structure is divided into two main branches only, which do not further branch in *B. australiensis*, *B. cyrensis*, *B. ornata*, *B. longirostris*, and *B. proboscida*. The two new species may be readily distinguished from one another and from *B. frondosa* by the form of the frontal appendage, the size of the body, and the relative proportions of the body and of its appendages.

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EXPLANATION OF PLATES.

Plate IV.

All figures refer to *Branchinella mirabilis*, sp., nov.

Figure 1. Lateral view of *Branchinella mirabilis*, male specimen.
" 2.—Anterior view of head of same, showing relationship of claspers and frontal appendage when latter is not in use.
" 3.—Head of female (Dorsal view).
" 4a.—Frontal appendage showing right half uncoiled.
" 4b.—One branch of same enlarged.
" 5a.—Egg sac and related segments of body in the female.
" 5b. Lateral view of female aperture closed.
5c.—Lateral view of female aperture open.
" 5d.—Ventral view of female aperture.
" 6. Mature egg.
" 7. Penes of male everted.

Plate V.

All figures refer to *B. mirabilis*, sp., nov.

Figure 8.—3rd Thoracic limb of male.
" 9.—8th Thoracic limb of female.
" 10. Claspers (Antennae of male).
" 11.—Antenna of female.
" 12. Antennule of female.
" 13.—Labrum.
" 14.—Mandible.
" 15. Maxilla.

Plate VI.

All figures refer to *B. wellardi*, sp., nov.

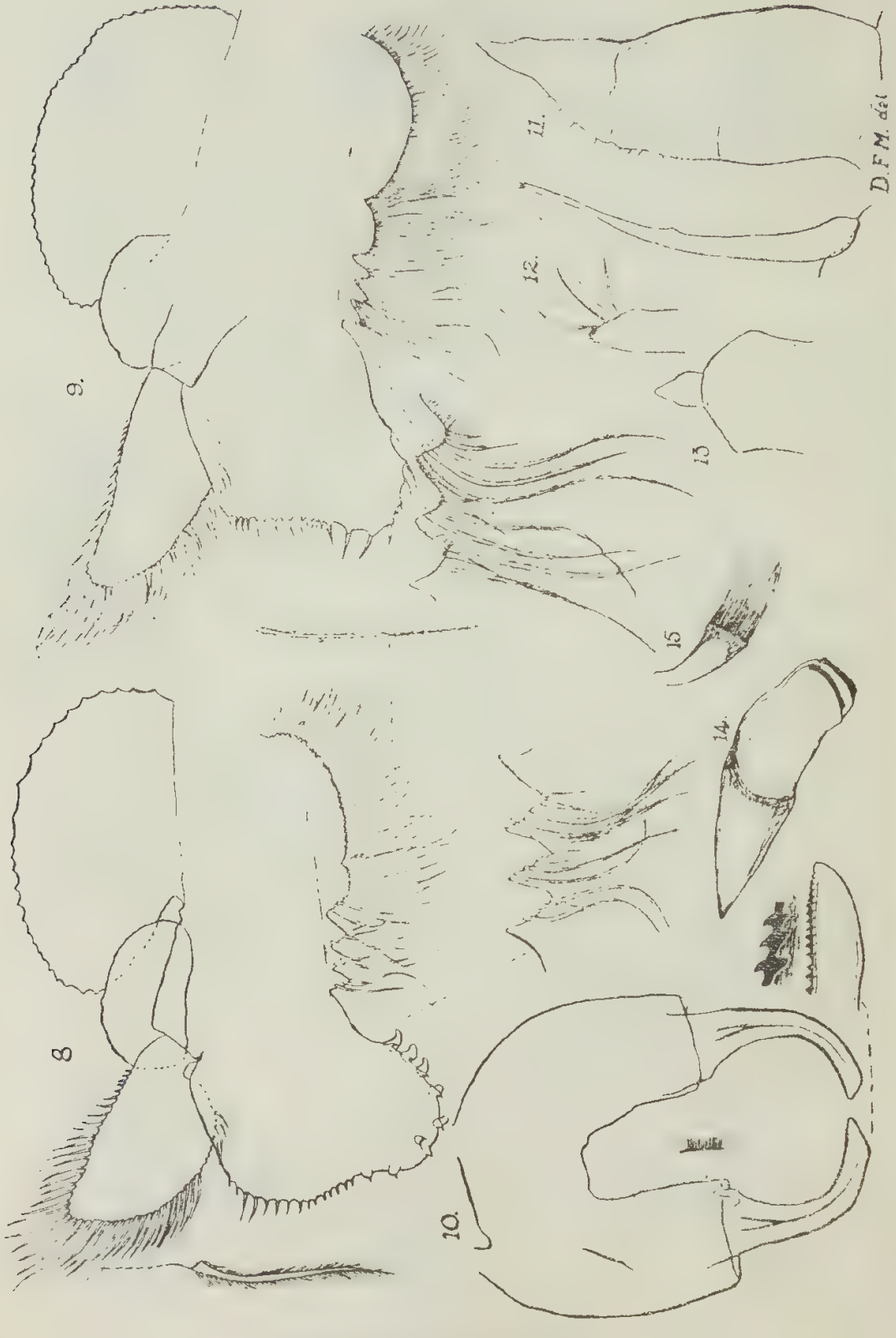
Figure 1.—Latera, view of *Branchinella wellardi* (male).
" 2. Dorsal view of head of female.
" 3.—Ovisac of female and related segments.
" 4a.—Frontal appendage showing right half uncoiled.
" 4b.—One branch of same enlarged.
" 5. Claspers (Antennae of male).
" 6.—Penes of male everted.
" 7.—Eighth Thoracic limb of male.

PLATE IV.

Brachiacha mirabilis, sp. nov.

Figures 1-7.

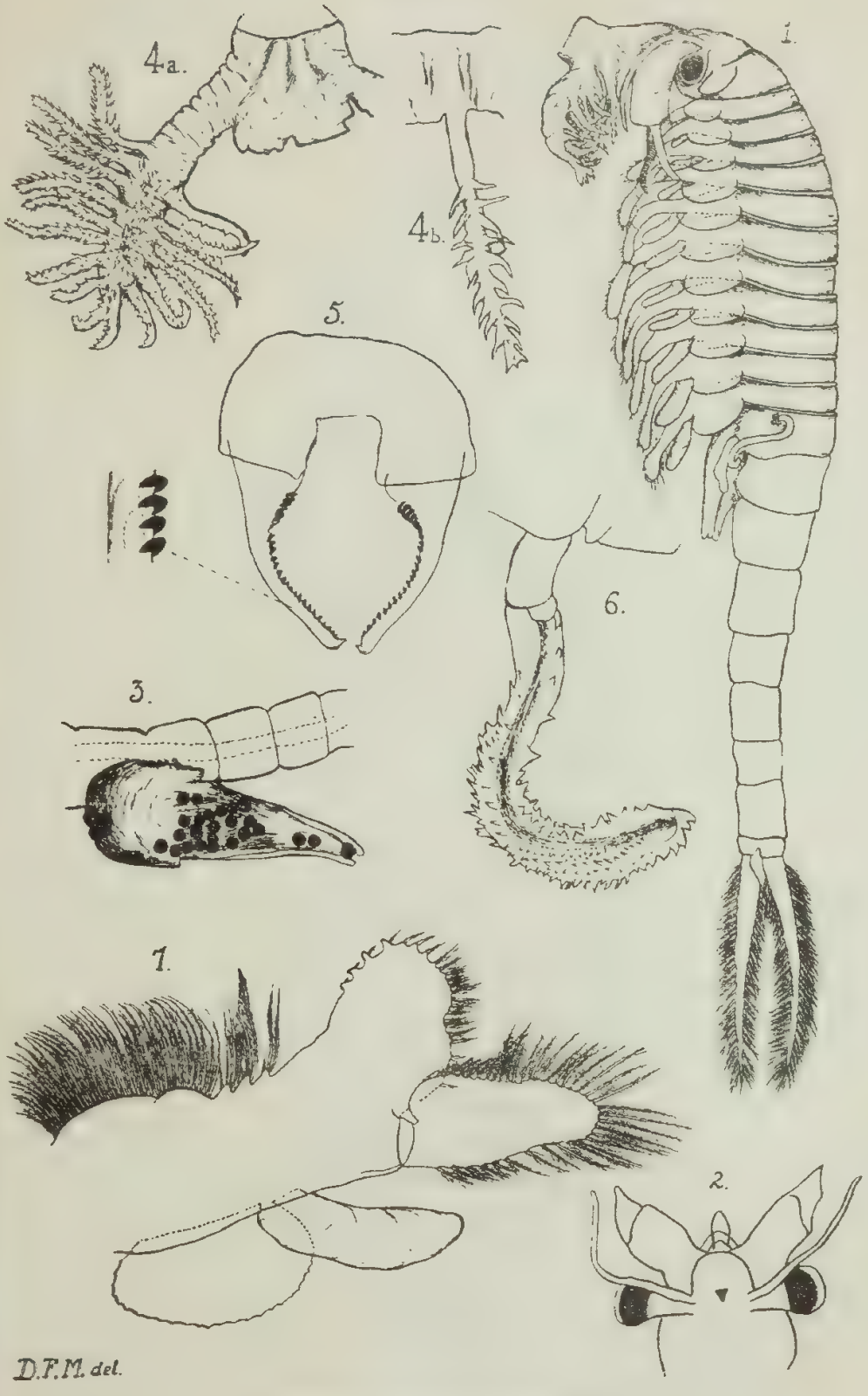
PLATE V.



Brachinella mirabilis, sp. nov.

Figures 8-15.

PLATE VI.



Branchinella wellardi, sp., nov.

Figures 1-7.

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5. CONTRIBUTIONS TO THE FAUNA OF ROTTNEST ISLAND.

No. I.

Introduction and Vertebrates.

(With one Plate VII.)

By

L. Glauert, B.A., F.G.S.

Curator of the Western Australian Museum.*

(*Read 14th August*, 1928. *Published 27th March*, 1929.)

Rottnest Island lies about 12 miles westerly of Fremantle, the port at the mouth of the Swan River, and is the first glimpse of Australia obtained by vessels approaching the Continent from South Africa and Ceylon. The island, which forms the northern extremity of two submerged ridges, the Five Fathom Bank, and that of which Garden Island and Carnac are elevated portions, is rather limited in extent. It measures less than seven miles from east to west and has a maximum north to south diameter of about 3½ miles. The surface of the island is irregular, the highest point, Lighthouse Hill, 154 feet, is situated close to the centre of the island and overlooks much low lying land to the north and east, including the numerous and extensive Salt Lakes, which in the winter time present most charming expanses of water whose place is taken by glistening stretches of snow-white salt in the later summer months, the area of the water being considerably reduced.

In the main, the land rises towards the north and west, where the "coastal limestone series" of which it is composed, has weathered to form rugged cliffs and prominent headlands separated here and there by smooth sandy beaches which vary with the season. The sand from these beaches is blown inland by the winds and has given rise to sandhills which fortunately are more or less anchored by the established vegetation. On the adjacent mainland this encroachment is slowly but surely advancing in spite of the efforts made to control it, and we may assume that the same is occurring upon Rottnest. At the "west end" some of these sandy patches are tunnelled like a rabbit warren owing to the activities of the Petrels that have selected this part of the island as the site of a breeding colony.

The surface soil is generally white and rich in lime and to it is added a certain amount of humus in sheltered corners in the hollows, and particularly near the few small freshwater swamps to be found here and there on the island. On the flats between the hills in the north-eastern quadrant marly soil with *Coxiella* is either exposed on the surface or covered with a thin layer of sand. The rich animal life in the lakelets and pools of this area contrasts very markedly with that of the salt lakes whose fauna seems to be limited to the larvae of a dipterous insect (? *Ephydra* sp.) Phyllopods (*Artemia salina*) and the Oniscids. *Haloniscus* and *Deto*.

Much of the island is clothed with dense wattle scrub tangled with creepers and undergrowth and traversed in all directions by the runs of *Setonyx brachyurus* and by the tracks opened up to facilitate the passage of visitors from place to place or to provide the firewood used in the settlement during the summer season.

[v9474.]

* By permission of the Trustees.

The first reference to the fauna of Rottnest is that made by Samuel Volckersen, skipper of the "Waeckende Boey," which visited the island in 1658; he states "here certain animals are found, since we saw many excrements, and besides two seals and a wild cat, resembling a civet cat, but with browner hair (*S. brachyurus*)†. Willem de Vlamingh sighted the coast on December 29th, 1696, and landed a party on the island. Two days later he remarked "There are very few birds there and no animals, except a kind of rat as big as a common cat, whose dung is found in abundance over all the island. There are also very few seals or fish."‡

In 1801, the French vessels "Géographe," and "Naturaliste" visited Western Australian waters, the latter reaching Rottnest on June 14th, where exploration and collecting were undertaken by the naturalist Bailly and others, the "civet cat" or "Kind of cat" of the earlier Dutch visitors, being identified as a "small species of Kangaroo."* Mention of snakes which are said to be fairly common is also made, and of lizards, presumably a species of *Lygosoma*.

Captain P. P. King visited the island in the "Bathurst," January, 1822, when his people saw many seals, the traces of a small kangaroo, a hawk, a pigeon and some sea birds, besides innumerable shells on the beaches of the Salt Lakes.† Seven years later Dr. T. B. Wilson and others, from the disbanded Raffles Bay Settlement, spent some time on Rottnest; the dogs catching two wallabies, and a member of the party shooting a snake about 5ft. long.‡

During the next 70 years little has been added to our knowledge of the land fauna of the island, until Mr. F. Lawson spent some time there making an extensive collection of birds skins which are now housed in the Museum. Twenty nine species were recorded of which only one, the *Ptilotis insularis* of Milligan,* showed any traces of the effects of long isolation. Mr. Lawson's field notes subsequently appeared in the "Emu."§

Additions to Lawson's list were made by Mr. O. H. Lipfert, who spent some time on the island in July, 1909; by Mr. D. L. Serventy, who has kindly allowed me to make use of his manuscript notes, and as a result of my recent visits.

Reptiles and Amphibians were collected by Dr. W. Michaelsen in 1905.** It was not my good fortune to obtain specimens of all of these, although I was able to add to the list.

MAMMALS.

Setonyx brachyurus Quoy & Gaimard. Quokka, Rottnest Island Wallaby.

This little Wallaby is quite plentiful on the island, being met with in all districts, including the vicinity of "The Settlement." The prohibition of firearms and the control of dogs on the island are wise provisions made by the Board of Control. It is much to be regretted that some wanton destruction is indulged in by youthful visitors during the summer months, when adequate supervision is impossible.

† ALEXANDER. Jour. W.A. Nat. Hist. and Sci. Soc. V. 1914, pp. 52-53.
‡ ALEXANDER. Jour. W.A. Nat. Hist. and Sci. Soc. V. 1911, pp. 54.
* ALEXANDER. Jour. Roy. Soc. W.A. I. 1914-5 (1916), p. 100.
† ALEXANDER. Jour. Roy. Soc. W.A. I. 1914-5 (1916), p. 125.
‡ ALEXANDER. Jour. Roy. Soc. W.A. III. 1916-7 (1918), p. 59.
* MILLIGAN. "The Emu" XI. p. 194. 1911.
§ LAWSON. A visit to Rottnest Island, Emu Vol. IV. 1905, p. 129.
** WERNER. Fauna Sudwest Australiens, II., parts 16 and 25.

BIRDS.

Eudyptes cristatus Miller, Crested Penguin.

A single specimen came ashore alive during Lipfert's visit to the island in 1909. The bird is in the W.A. Museum.

Phaps elegans Temm, Bush Bronze Wing.

I am informed that this Pigeon can be seen in a large patch of thick wattle scrub on the flat to the north of the Lighthouse Hill. This is not unlikely, for the species is to be found upon Garden Island.

Podiceps poliocephalus Jardine and Selby, Hoary headed Grebe.

A specimen of this widely distributed species has been seen on Garden Lake by D. L. Serventy, in March, 1927.

Podiceps Ruficollis Vroeg, Little Grebe or Dabchick.

Serventy noted a single specimen on Lake Bagdad in January, 1925.

Puffinus pacificus Gmelin, Wedge-tailed Petrel.

This species breeds in large numbers near Cape Vlaming, where sandy patches above the cliffs are often honey-combed with their burrows. Five specimens were collected 17th September, 1928. The birds were inhabiting the burrows in pairs, but no eggs were obtained, although six or seven nests were examined. Serventy noted young birds and eggs in January, 1925.

Macronectes giganteus Gmelin, Giant Petrel.

A specimen was caught at the Long Jetty, Thompson's Bay, on 19th September, 1928, by a Mr. Jarvis, who was fishing there at the time.

Diomedea chlororhyncha Gmelin, Yellow nosed Albatross.

I saw remains of a specimen during my visit, September, 1927.

Phalacrocorax varius Gmelin, Pied Cormorant.

It is not surprising that this species should be found on the island as it frequents the coastal waters of the adjacent mainland. The bird's presence was first noted by D. L. Serventy, it was also seen in September, 1927, and September, 1928.

Sterna bergii Lichtenstein, Crested Tern.

This handsome Tern was seen everywhere around the coast. Large flocks were seen on the Lady Edeline Beach and in Salmon Bay. There must have been at least a thousand birds in each flock.

Sterna nereis Gould, Fairy Tern.

This species was seen daily by D. L. Serventy during a week's stay in January, 1925. One or two individuals were seen by F. Lawson. W. B. Alexander states that it breeds on the island. Serventy found eggs and nestling on an islet in one of the salt lakes in January, 1925.

Sterna anaetheta Scopoli, Bridled Tern.

Breeds on the islets off the shore where the single egg is laid in a crevice in the limestone rock. Seen by Serventy on many occasions.

Larus novae hollandiae Stephens, Silver Gull.
Very plentiful everywhere.

Gabianus pacificus Latham, Pacific Gull.
A few birds were seen off the northern shore of the island in September, 1927. The species is also recorded by Alexander.

Arenaria interpres Linne, Turnstone.
This species has been seen by Lawson, Lipfert and Serventy. Specimens obtained by Lipfert are in the Museum.

Haematopus ostralegus Linne, Pied Oyster Catcher.
This species is a rare visitor.

Haematopus unicolor Forster, Sooty Oyster Catcher.
Mr. Lawson records the species from the West End. Alexander remarks "a few on rocky parts of the coast, especially Rottnest Island."

Erythrogonys cinctus Gould, Red-Kneed Dotterel.
The species is said to have been seen on the island in the winter time.

Pluvialis dominicus P. L. S. Muller, Eastern Golden Plover.
A specimen, Cat. 1135, was presented to the Museum in 1903, by a Trustee, Dr. H. T. Kelsall, who obtained it on the island. Alexander states that flocks are to be seen on the island in the summer time.

Charadrius cucullatus Vieillot, Hooded Dotterel.
Lawson records a few specimens in company with other Waders.

Charadrius ruficapillus Temminck, Red-Capped Dotterel.
This species is very common on the various beaches, it breeds upon the islands.

Cladorhynchus leucocephalus Vieillot, Banded Stilt, or "Rottnest Snipe."
The species visits the Salt Lakes in large numbers during the summer months. Lawson says "they are very wary and on being disturbed fly to the centre of the lagoon, where they float lightly on the water." Alexander says they are winter visitors, but Serventy saw them in the summer. I have not seen the birds during my visits.

Recurvirostra novae hollandiae. Vieillot, Red-Necked Avocet.
Alexander says the species sometimes visits Rottnest.

Erolia testacea Vroeg, Curlew Sandpiper.
A common summer visitor. Several specimens are in the Museum Collection of Rottnest Birds.

Erolia ruficollis Pallas, Red Necked Stint, Little Stint.
A winter visitor, found on Rottnest. The Museum has specimens collected by Messrs. Baird, Conigrave and F. Lawson.

Erolia acuminata Horsfield, Sharp-tailed Sandpiper.
Visits the island in the summer months. It has been collected in November by Baird and Lawson.

Threskiornis spinicollis Jameson, Straw-necked Ibis.
Serventy saw this bird on the island in March, 1927.

Notophoyx novae hollandiae Latham, "Blue Crane."
Several specimens were seen on the Salt Lakes and upon the smaller swamps in August and September, 1927.

Demigretta sacra Gmelin, Reef Heron.
A few occur on the rocky portions of the coast ; they are said to breed on some of the islets. A specimen from the island (4856) is in the Museum. Serventy also notes the presence of the bird. A white individual, the *D. greyi* of certain authors, was seen at close quarters near North Point on September 13th, 1928.

Casarca tadornoides Jardine and Selby, Mountain Duck.
Many specimens were seen on the Salt Lakes, in one case the mother was accompanied by a large number of young—over 12 in all. In September, 1928, a family of 20 young was observed on Government House Lake.

Anas superciliosa Gmelin, Black Duck.
Lawson records the presence of this species which I can confirm as a result of the visit August-September, 1927.

Falco berigora Vigors & Horsfield, Brown Hawk.
Lawson says that the bird is not uncommon, its presence is confirmed by Serventy. I saw it near "the Neck."

Falco cenchroides Vigors & Horsfield, Nankeen Kestrel.
This species is said to be rare, It is, however, represented by Rottnest specimens in the Museum. One was seen "hovering" near Point Clune on several occasions, September, 1928 ; also seen at Bathurst Point, 12th October, 1928.

Pandion haliaetus Linne, Osprey or Fish Hawk.
Lawson found the bird breeding on the island, and Serventy confirms the record of the Bird's presence. I did not see it last year, but saw on overhead at Point Vlaming on September 18th, 1928. In addition to the old nest in Eagle Bay a second is now established in Lady Edeline Bay near the neck.

Ninox boobook Latham, Boobook Owl.
A fine specimen was seen in a tree near Bungalow 13 in August, 1927. It is not surprising that this nocturnal bird was not recorded earlier.

Neophema petrophila Gould, Rock Parrot.
This species is to be met with all over the island in small flocks. It is well represented in the Museum. A clutch of four eggs was obtained near North Point on September 13th, 1928.

Cuculus pallidus Latham, Pallid Cuckoo.
Lawson met this species sparingly.

Cacomantis flabelliformis Latham, Fan-tailed Cuckoo.

This species was first recorded by Lipfert, who obtained specimens in 1909.

Lamprococcyx plagosus Latham, Golden Bronze Cuckoo.

Like the preceding, Lipfert's record was substantiated by means of specimens.

Hirundo neoxena Gould, Welcome Swallow.

This swallow first recorded by Lawson, confirmed by Lipfert and Serventy, the former of whom collected specimens. The bird is quite plentiful near the settlement.

Hylochelidon nigricans (Vieillot, Tree Martin.

Serventy supplied the first record for this species; a single bird was seen in January, 1925.

Petroica goodenovii Vigors & Horsfield, Red Capped Robin.

This Robin is plentiful on Rottnest where it breeds regularly. It is very rare on the adjacent mainland though common further inland, the bird's presence on Rottnest is therefore significant for it cannot well be assumed that it is a recent immigrant introduced by strong easterly winds. Like the Quokka and the Rottnest singing Honey-eater, it is probably a very old resident.

Pachycephala pectoralis Latham, Golden Whistler.

Specimens are in the Museum. They were collected by O. H. Lipfert in 1909. I saw several near North Point in September, 1927.

Pachycephala rufiventris Latham, Rufous Whistler.

The existence of this bird is confirmed by specimens in the Museum. Serventy also records it.

Grallina cyanoleuca Latham, Magpie Lark.

I heard the call of this bird close to a freshwater swamp in the vicinity of North Point. Mr. Pearce, a resident, tells me that six or eight birds made their appearance on the island during the winter of 1928. He saw a specimen in August, about a week before I heard the call.

Coracina novae-hollandiae Gmelin, Black-faced Cuckoo Shrike.

This species was seen several times to the west of the Settlement in 1927 and 1928. A specimen (5757) is in the Museum.

Lalage tricolor Swains, White shouldered Caterpillar Eater.

Three specimens from the island (6359 61) are in the collection, they were collected by C. P. Conigrave in 1903.

Ephthianura albifrons Jardine & Selby, White-fronted Chat.

This striking little bird was met with in all parts of the Island in 1927 and 1928. As on the adjacent mainland the species is usually seen moving about in small flocks, its call is very distinctive and often betrays its presence before the bird is seen. Lipfert collected specimens in 1909.

Sericornis maculata Gould, Spotted Scrub-wren.

This little bird which is not uncommon on the coastal sandhills; occurs also on Rottnest.

Zosterops australasiae Vieillot, Western Silver Eye or Greenie.

This species is very common on the island. It is not at all shy and will come close to habitations searching for crumbs and so forth. Specimens were collected by Lipfert in 1909.

Meliphaga virescens Vieillot, Singing Honey-eater.

This is quite common on the island. Milligan* regarded the island form as a distinct species, *M. insularis*, because of its markedly darker colouration, but the R.A.O.U. Check List of 1926 will not recognise more than sub-specific rank for this form. Specimens collected by Lipfert are in the Museum collection.

Anthus australis Vieillot, Australian Pipit.

The bird is not uncommon on the open country where grass abounds. Specimens in the Museum were obtained by Lipfert in 1909.

Corvus coronoides Vigors & Horsfield, Australian Raven, Crow.

Both white-eyed and hazel-eyed individuals were seen. Crows are very abundant, even in the settlement where they are unmolested.

SNAKES.

Few species of snakes seem to be represented on the Island to-day. This may be a peculiarity due to natural causes or it may have resulted from the fact that for many years Rottnest was a penal settlement for native prisoners, who for some years, at any rate, were rewarded for every large snake they killed and submitted to the local authorities for inspection.

Typhlops australis Gray, Common Blind Snake.

A specimen of this burrowing snake was obtained by Prof. W. Michaelsen during his visit to the island in September, 1905 †

Demansia nuchalis Gunther, Brown Snake.

Dr Michaelsen collected three specimens, there is one example in the Museum, and a specimen was seen near the Settlement in September, 1928.

Notechis scutatus Peters, Norne or Tiger Snake.

I am of opinion that I saw a specimen near the "west end" on the 17th September, 1928. Conversation with residents of long standing tend to support this, several of them described a Black Snake that showed fight and flattened its neck when roused, these features are well known characteristics of the Norne.

LIZARDS.

Little is known about the Lizards of the Island. In 1905 Dr. W. Michaelsen collected representatives of eight species, and during my two visits I obtained five of these and added *Egernia striolata*. I have no doubt that future visits will add to this exceedingly small list. It is curious that no Geckoes have yet been found. ‡

* A. W. Milligan. The Emu XI., p. 124. 1911.
Fauna Sudwest Australiens, II., part 16. 1909. p. 256. Also op. cit., p. 257.

‡ Since the above was written a party of campers, under the aegis of the Y.M.C.A., obtained specimens of *Phyllodactylus marmoratus* (Gray) and *Diplodactylus spinigerus* (Bluge) during January, 1929.

Lialis burtoni Gray.

This active little scale-footed Lizard is widely distributed, specimens were caught near Serpentine Lake and near Garden Lake. It was also recorded by Michaelsen.

Trachysaurus rugosus Gray.

One afternoon seven specimens were seen on a flat to the south of Government House Lake. One specimen was taken as a record.

Egernia kingii Gray.

This species was collected by Dr. Michaelsen, I believe I saw a specimen near Bathurst Point in 1927.

Egernia striolata Peters.

Specimens were caught on Mt. Herschell, and near Serpentine Lake in 1927 1928. It had not been previously recorded.

Lygosoma lesueuri Dum & Bibr.

A specimen of this active lizard was caught near Mt. Herschell, it had been seen previously in many localities along the north coast of the Island.

Lygosoma quadrilineatum Dum & Bibr.

This little lizard is everywhere. Eight specimens were obtained at North Point, Bathurst Point, Salmon Bay, Bickley Swamp and on the South shore of Government House Lake.

Lygosoma praepeditum Boulenger.

This almost legless lizard was collected by Dr. Michaelsen, 1905.

Ablepharus lineo-ocellatus Dum & Bibr.

Two specimens were obtained near Lake Herschell in 1927.

Ablepharu elegans Gray.

This lizard is included in the list on Dr. F. Werner's determination of species collected by Dr. Michaelsen.

BATRACHIA.

The conditions upon Rottnest might be considered unfavourable for the development of Amphibians, yet four species are already known from the island, and it is probable that others, including *Myobatrachus gouldi*, will be discovered in the near future, the island being far more hospitable than the Abrolhos where the latter species was obtained many years ago.

Limnodynastes dorsalis Gray.

Tadpoles presumed to belong to this species were obtained by Dr. Michaelsen. They were found to be plentiful in small freshwater pools to the west of the Bungalows in September, 1927, and 1928.

Heleioporus albopunctatus Gray.

This species was also collected by Dr. Michaelsen. I did not see it during my two visits.

Crinia signifera Gray.

This little froglet was found under stones in many parts of the island and specimens were obtained near Bickley Swamp, near the old Salt Works, and near Ursula's Lake, a freshwater pool to the west of the Bungalows.

Hyla aurea Lesson.

This species does not seem to be common, we found it near Garden Lake, but it was not noticed near any of the more or less permanent swamps where its presence might have been expected.

SUMMARY.

It is a curious feature of the distribution of our mammals that the Wallaby on the island should differ from the species of *Thylogale* found on the Abrolhos and upon Garden Island. Further, it must be noted that whilst the Thylogales on the Abrolhos and upon Garden Island are readily distinguished from the mainland forms ; here is no apparent difference, except perhaps that of size, between the Rottnest *Setonyx* and that still living in swamps near Perth. In this connection it must be remembered that *Setonyx brachyurus* is, in the opinion of Professor F. Wood Jones, one of the most highly specialised of the Macropodidae and with *Dendrolagus* and *Dorcopsis* it comprises the brachydont section of the sub-family Macropodinae. *Setonyx* is confined to our South-West.

The birds offer no such marked peculiarities, their power of sustained flight enables most of them to cover 10 or 20 miles with ease, but mention must again be made of the abundance of the Red-Capped Robin and the distinct colouration of the island form of the Singing Honey Eater. Of the 12 land birds occurring on the Abrolhos six occur on Rottnest, the absence of the Quail, Rail, and Crake, may perhaps be accounted for by the fact that the island was formerly a penal settlement for native prisoners, who were given conisderable liberty.

As far as we know at present, the species of Snakes recorded for the Abrolhos do not occur on Rottnest, which, however, presents no unusual feature when compared with the adjacent mainland.

Among the Lizards, Agamids and Varanids seem to be unrepresented. *Delma fraseri*, which is known from the Abrolhos, has not yet been met with, though present near Perth, and of the Skinks Rottnest and the Abrolhos have five species in common ; whilst three Abrolhos species do not occur on Rottnest, *Egernia striolata*, *Ablepharus lineo ocellatus*, and *A. elegans* are absent from the northern group of islands.

Of the four Batrachians on Rottnest, *Limnodynastes dorsalis* and *Crinia Signifera* are present on the Abrolhos and on the mainland, near Perth, whilst *Heleioporus albopunctatus* (auctorum) and *Hyla aurea* which occur in the Metropolitan area are absent on the Abrolhos. The Hylid on the Abrolhos is the northern *Hyla rubella*. The fourth Abrolhos species, the remarkable *Myobatrachus gouldi*, is known from near Geraldton and further south, but has not yet been reported from Rottnest, though it may occur there.

Mr. Alexander* has referred to the strikingly southern character of the Abrolhos land fauna, but the resemblance is closer to the southern mainland than to Rottnest. There are peculiarities in the animal life on Rottnest that are rather suggestive of long isolation, whilst now and again, as in the Skink *Egernia striolata* and in the Red Capped Robin, we have suggestions of an affinity with the Darling Range rather than with the intervening Coastal plain. The evidence of certain land invertebrates points in the same direction.

* Jour. Lin. Soc. Zool. XXXIV. Feb. 1922. p. 467.

PLATE VII.

Map of Rottnest Island.

By Authority: FRED. WM SIMPSON, Government Printer, Perth.

6. CONTRIBUTIONS TO THE FAUNA OF ROTTNEST ISLAND.

No. II.

POLYPLACOPHORA.

(With Seven Figures 10–16.)

By
EDWIN ASHBY, F.L.S., ETC.

Communicated by L. Glauert.

(*Read 14th August*, 1928. *Published 27th March*, 1929.)

I have been asked by Mr. L. Glauert, Curator of the Western Australian Museum, Perth, to determine and describe a small collection of Chitons, made by himself at Rottnest Island. He has suggested that this form the second of a series of papers on the fauna of this Island and that in it be included any published records from the same locality. The collection now described is not numerically extensive but is of exceptional interest in that it contains two species hitherto undescribed, one a most striking new form of *Notoplax* and the other a little inconspicuous member of the genus *Lepidopleurus*; both these are described and figured.

At the end of this paper is presented a brief resume of the revised classification of Polyplacophora proposed by the writer in consequence of a recent discovery of a connecting link between palaeozoic forms and one phylum of living chitons, viz., that of the ACANTHOCHITONIDAE. This hitherto missing link was discovered in the Oligocene (Balcombian) beds, near Mornington, Victoria, and its characters fully described by the writer under the generic name *Protochiton*, in his monograph on Australian Fossil Polyplacophora (Proc. Roy. Soc. Viet., vol. xxxvii. (New Series), Pt. II., pp. 170–205, 1925.)

FAMILY ACANTHOCHITONIDAE.

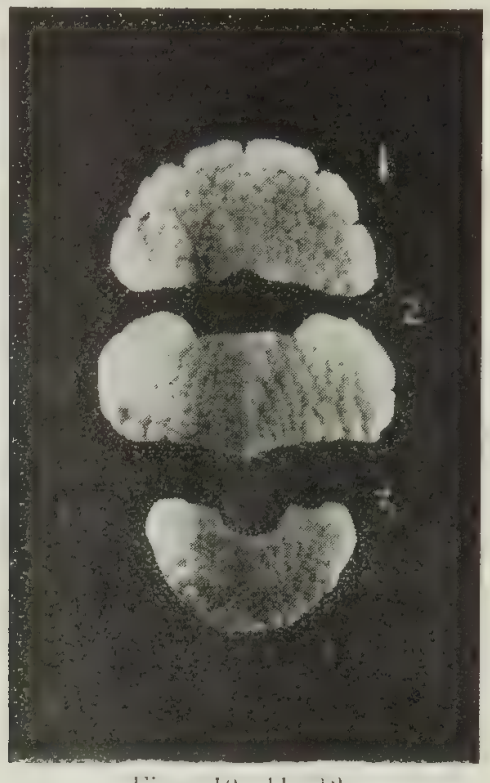
Notoplax rottnestensis n. sp.

General appearance.– Elliptical, carinated, girdle very broad, slightly encroaching at the sutures, appearing under a simple lense leathery; shell very strongly sculptured with coarse granules, diagonal fold or rib well defined, as also are the five ray ribs of the anterior valve, blotched green, pink and white.

Anterior valve.–Possesses five ray ribs or folds, corresponding with the five slits, the whole surface decorated with closely packed, highly raised, convex granules, mostly circular but becoming rapidly larger and more ovate towards the girdle each grain overhangs its base, making the interspaces unusually deep.

Posterior valve.– Mucro slightly anterior of median, well defined, the slope immediately behind the mucro steep and devoid of granules, dorsal area slightly raised and pinnatifid, smooth: the portion anterior to mucro decorated with longitudinal rows of irregular, coarse, raised grains, which are less convex and more widely spaced than is the case on the other valves; the posterior portion is separated from the anterior by a fold surmounted by irregular grains fully three times the size of those on the anterior portion

of this valve ; the rest of this area is closely covered with three rows of large rounded grains placed more or less concentrically, the larger grains to the outside but not equalling those surmounting the fold.



Figs. 10, 11, 12.

Notoplax rottnestensis, Ashby, Rottnest Is.;
(1) Holotype, anterior valve. W.A. Mus., X $6\frac{1}{2}$.
(2) Holotype, median valve. W.A. Mus., X $6\frac{1}{2}$.
(3) Holotype, tail valve. W.A. Mus., X $6\frac{1}{2}$.

Median valve.- Valve No. 6, arched rather flat, sideslope slightly convex, angle of divergence 105°; dorsal area well defined, strongly pinnatifid. I count six lateral notches, surface smooth : pleural area crossed irregularly by eight rows of large, irregular, highly-raised, slightly convex grains; those nearest the girdle are longitudinal but becoming more and more diagonal as they approach the dorsal area; some grains abutting on the dorsal area near the anterior margin are elongate, three times as long as wide ; the lateral area is separated from the pleural by a diagonal fold which is surmounted by large grains twice the size of the others, but otherwise similar to those of the pleural area ; the rest of the lateral area is similar to the pleural.

Articulamentum.- White, anterior valve slits five and deeply cut, teeth smooth-edged but thick, insertion broad and grooved, upturned at the slits on the upper side ; tail valve, teeth irregular, slits 10 ; median valve, callus present but not pronounced : slits 1/1, insertion thickened and upturned at slit, teeth sharp, sutural laminae broad and rather shallow, sinus between very broad and notched at either side.

Girdle.- Twice the width anteriorly that it is posteriorly, under simple lense has a felty appearance, possesses a girdle fringe composed of a single row of short spicules, hair-tufts are not conspicuous, the tufts when not broken consist of about five slender curved spicules which are tinged with green ; there is in one specimen a broad black band across the girdle immediately behind the anterior valve ; under 62 mag, the girdle is seen to be densely clothed with minute, flat, smooth, highly polished scales, set almost vertically so that the edges give the felty appearance before referred to.

Measurements.—Holotype curled and not measured, paratype figured dry 16·5 x 9·5 mm., holotype anterior valve 4·5 x 3 mm., tail valve 3·5 x 2·5 mm., median valve 5 x 2·5 mm., angle of divergence 105°.

Habitat.—Bathurst Point, Rottnest Island, Western Australia.

Paratypes.—(a) Has a blue-coloured girdle, valve 2 mauve, others green; (b) has blue girdle, all valves green; (c) has mauve-coloured girdle and valve 2, rest of valves green. There are two varieties each, of these other examples represent further variations of same colours.

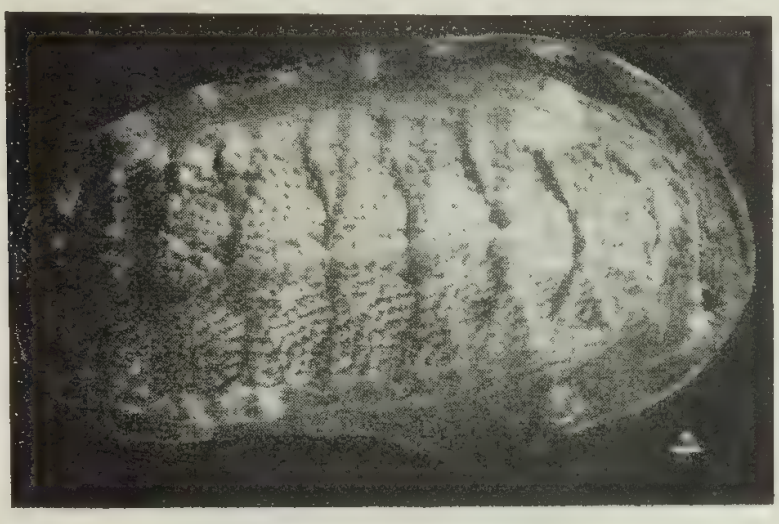


Fig. 13.

Fig. 13. *Notoplax rottnestensis*, Ashby, Rottnest Is.; Paratype, whole shell, Ashby. coll., X 5.

Comments.—In one example the ray folds of the anterior valve are surmounted by long finger-like, convex granules, and the dorsal area has in some valves a marginal rib. This species differs from *A. subviridis* Torr. in that in the latter species the girdle is clothed with adpressed spicules and the sculpture consists of flat grains, whereas in the species under review the upper girdle clothing is arenaceous and the sculpture is composed of pebble-like grains. This striking species differs widely from any other Acanthoid Chiton and approaches most nearly to the subgenus *Amblyplax* Ashby; the sculpture and the thickened, short, multislit insertion of the tail valve strongly suggest that it is a true representative this subgenus hitherto only known from New Zealand waters, and nearest to *Notoplax* (*Amblyplax*) *foveauxensis*, (Ashby), but I will leave the final determination of this point to future study

Sub-family CRYPTOPLACINAE.

Cryptoplax striatus var. **westernensis**, Ashby.

Ashby (Trans. Roy. Soc. S. Aust. vol. xlvii, p. 238, 1923).

Seven examples of this shell were collected by Mr. Glauert at Bathurst Point. Ashby collected one example at the steamer landing on Rottnest Island in 1920, and proposed the varietal name quoted above for this form on the following grounds; "It differs from the typical shell (type locality Kangaroo Island South Australia) in that it shows no sign of the granulose sculpture of the juvenile; it seems from the start to commence the coarse longitudinal ridges, also the spicules of the girdle are both shorter and more

slender than is the case of typical *striatus*." The examples now under review all exhibit the difference in sculpture referred to above, but show rather less variation in the girdle spicules than does Ashby's type. If these characters are constant when a larger series are available from this locality then *westernensis* will deserve subspecific rank.

Lepidopleurus glauerti n. sp.

In the collection made by Mr. Glauert are five examples of a minute Chiton, all curled and preserved in spirit, several with valves detached. I have pleasure in naming this new form after the discoverer, Mr. Glauert.

General appearance. Elongate, elevated, carinated: decorated with elevated, circular convex granules which under a simple lense show but little systematic arrangement. The girdle is covered with small, imbricating scales; there is a girdle fringe, colour dirty white to creamy white.

Anterior valve. Slope steep, convex, and valve more elevated than either *L. badius* or *L. matthewsianus*; two strong concentric growth grooves are showing in type, surface evenly decorated with circular, raised convex grains.

Figs. 14, 15, 16.

(5) *Lepidopleurus badius*,
H. and H., N.S.W., Paratype, whole shell, side view, Ashby, coll., X 6.

(6) *Lepidopleurus matthewsianus*,
Bed., S. Australia, whole shell, side view, Ashby, coll., X 6.

(7) *Lepidopleurus glauerti*,
Ashby, Rottnest Is.; Holotype, whole shell, side view. W.A. Mus., X 6.

Posterior valve. The holotype has not been disarticulated, but the smallest specimen, only about one-fourth the size, has a detached tail valve; in this the mucro is antemedian situated at the anterior third (but in this genus there is a good deal of variation in the position of the mucro within the compass of the same species), the mucro is well def'ned and the posterior slope concave, but in the small example the posterior portion of this valve is flatter than is the case in the holotype; in this latter the mucro appears almost median; the sculpture consists of similar circular grains to those in the anterior valve.

Median valve. The dorsal areais ornamented with longitudinal rows of circular, convex grains, these rows continuing in the pleural area but there becoming rapidly indistinct ; the grains increase in size and elevation towards the margin and the spacing becomes somewhat irregular ; there is no distinction between the pleural and lateral areas; the arrangement of the grains is, as has been before stated, indistint but more radial than longitudinal ; in the lateral area it is transverse not radial. In *L. mattheusianus*, the whole of the pleural area is ornamented with well defined, regular, longitudinal rows of low, partly coalesced granules, and the lateral area is raised and ornamentation radial ; in that as well as in *L. badius* the longitudinal rows are proportionally more widely spaced than is the case in *L. glauerti*.

Girdle.—Is clothed with small, loosely imbricating scales, there is a spiculose girdle fringe ; in the smallest example a few spicules, longer than these of the fringe, can be seen at the sutures. (As I have elsewhere pointed out, the girdle spicules in the Lepidopleuridae are usually very loosely attached, the presence or absence of such spicules cannot be considered of generic value, in fact owing to this, unless supported by more stable features the presence or absence of girdle spicules can hardly be accepted as of even specific value in members of this genus.)

Measurement. The holotype dry and curled is 5 x 3·5 mm.

Habitat.—Bathurst Point, Rottnest Island, Western Australia.

In conclusion.—The strong carination easily separates this species from *L. mattheusianus* Bed. As compared with *L. badius* the granular ornamentation is more elevated and the grains placed closer together, the shel more elevated and carinated and less broad, the side slope convex and steeper

Callochiton platessa, Gould.

Torr in (Trans. Roy. Soc. S. Aust. vol. xxxv., p. 96, 1911) records one example from Rottnest Island.

Plaxiphora albida, Blainville.
=P. costata, Blainville.

Torr (l.c.) records the finding of this species on Rottnest Island. The writer has found this shell common in suitable places where he has had the opportunity of collecting, as far north as Dongarra.

Ischnochiton torri H. and H.

In the collection made by Mr. Glauert is one example measuring 37 x 17 mm., quite a typical shell. Torr (l.c.) records under the name *I. ustulatus* (not of Reeve) several examples from Rottnest Island.

Ischnochiton virgatus, Reeve.

In the collection are eight examples of this beautiful little Chiton, which show no variation from those from the type locality in South Australia. Iredale and Hull under the name *Autochiton virgatus exaggeratus*, describe as a subspecies a large dark-coloured varient which also occurs in similarly sheltered situations in South Australia, it certainly cannot be considered a geographic race and cannot be recognised as having subspecific rank, neither do they advance sufficient grounds for the adoption of their proposed new genus *Autochiton*.

Ischnochiton ptychius, Pilsbry.

Torr (l.c.) records a single example taken off a buoy between Fremantle and Rottnest Island.

Ischnochiton contractus, Reeve.

= **I. decussatus**, Reve.

Torr (l.c.) records under the latter name the taking of two examples off the same buoy as the preceding.

Ischnochiton (Heterozona) cariosus, Pilsbry,
var. **occidentalis**, Ashby.

Ashby (l.c.) recorded the taking of a single example off the rocks at the landing place on Rottnest Island in 1920.

Torr (l.c.) records the taking of this species in numbers on the same island. I have elsewhere pointed out that the wisdom of retaining the name *Heterozona*, even subgenerically, is very doubtful as the chief character upon which the subgenus was founded (large scales scattered amongst the smaller ones) does not appear to be even of subgeneric value.

Chiton (Ryhssoplax) torrianus, H. and H.

Torr (l.c.) records this species from Rottnest Island.

Liolophura hirtosus (Peron, M. S.), Dall.

= **L. georgianus**, Quoy and Gaimard.

Torr (l.c.) records this shell from Rottnest Island. I have found this species which is endemic to Western Australia, most numerous wherever I have collected in that state as far north as Dirk Hartog Island.

Onithochiton scholvieni, Thiele.

Mr. Glauert collected one example measuring 45 x 20 mm. when dry, at Bathurst Point, and Torr (l.c.) recorded it under the name *O. quercinus* Gould, this latter being an Eastern Australia species, being common in New South Wales and Queensland, but does not seem to occur in the Northern Territory. This species I have also collected on the southern coasts and also found it most numerous on Dirk Hartog Island and have many examples from between Carnarvon and Maud's Landing.

ADDENDA.

Mr. Glauert has forwarded to me additional material collected by him at Rottnest Island during the month of September, 1928. While he obtained a good deal of interesting material of species recorded earlier in this paper, he has been successful in adding one additional species, viz., *Acanthochiton bednalli* var *johnstoni*, Ashby (Trans. Roy. Soc. S. Austr. vol. 47, p. 231, 1923). This variety was described from specimens obtained north of Carnarvon, Western Australia. In colour markings this beautiful variety is very distinct from normal *A. bednalli*, Pilsbry, but as pointed out in the description (l.c.) no character warranting specific rank has been detected. Mr. Glauert has secured one small specimen. He also has taken a beautifully coloured speci-

men of *Callochiton platessa*, Gould: this example is flesh-pink and differs in minor details from the eastern form but cannot specifically be separated. Thiele in *Fauna Sudwest-Australiens* (Polyplacophora, 1911) records the following from Rottnest Island. *Onithochiton scholeiensi*. Thiele, *Ischnochiton ustulatus* (non of Reeve = *I. torri* Iredale and May), *Ischnochiton virgatus* Reeve.

On the occasion of a brief visit to Rottnest on October 12th last, Mr. Glauert obtained a second specimen of *Acanthochiton bednalli* var *johnstoni*, Ashby, and also a juvenile example of *Callistochiton meridionalis*, Ashby.

The discovery that the Phylum ACANTHOCHITONIDAE was not derived from Palaeozoic stock through the family LEPIDOPLEURIDAE, but came through the Australian Fossil family PROTOCHITONIDAE, necessitates a partial revision of our previous conception of the classification of POLYPLACOPHORA. The following Classification in Brief, is presented with the intention of giving expression to this revised conception, chiefly as it affects those groups dealt with in the paper.

REVISED CLASSIFICATION OF POLYPLACOPHORA IN BRIEF.

Order **POLYPLACOPHORA**, Blainville.

I. Suborder **Eoplacophora** Pilsbry. Palaeozoic only.
Family Gryphochitonidae Pilsbry. Palaeozoic only.

II. Suborder **Protochitonina** Ashby.
Family **Protochitonidae** Ashby. Fossil only.
Family ACANTHOCHITONIDAE Hedley.
Subfamily AFOSSOCHITONINAE, Ashby. Fossil only.
Subfamily ACANTHOCHITONINAE, Ashby.
Genus Acanthochiton, Gray, em. 1821.
Genus Notoplax, H. Adams, 1861.
Notoplax rottnestensis, Ashby.
Subfamily CRYPTOPLACINAE, Thiele.
Genus Cryptoplax, Blainville, 1818.
Cryptoplax striatus Lam. var *westernensis*, Ashby, 1923.

III. Suborder **Lepidopleurina** Thiele.
Family **Lepidopleuridae** Pilsbry.
Genus Lepidopleurus, Risso, 1826.
Lepidopleurus glauerti, Ashby.

IV. Suborder **Chitonina** Thiele.
Family CALLOCHITONIDAE, Thiele.
Subfamily CALLOCHITONINAE, Thiele.
Genus Callochiton, Gray, 1847.
Callochiton platessa, Gould.
Family MOPALIIDAE, Pilsbry.
Genus Plaxiphora, Gray, 1847.
Plaxiphora albida, Blainville.

Family ISCHNOCHITONIDAE, Pilsbry.
Subfamily ISCHNOCHITONINAE, Pilsbry.
Genus Ischnochiton, Gray, 1847.
Ischnochiton torri, Iredale and May, 1916.
Ischnochiton cirgatus, Reeve, 1847.
Ischnochiton ptychius, Pilsbry, 1894.
Ischnochiton contractus, Reeve, 1847.
Ischnochiton (*Heterozona*), *cariosus*, Dall, 1878.
Family CHITONIDAE, Pilsbry.
Subfamily CHITONINAE, Pilsbry.
Genus Chiton, Linne, 1758.
Subgenus *Rhyssoplax*, Thiele, 1893.
Chiton (*Rhyssoplax*) *torrianus*, Hedley and Hull, 1910.
Subfamily LIOLOPHURINAE, Pilsbry, 1893.
= ACANTHOPLEURINAE, Thiele, 1910.
Genus Liolophura, Pilsbry, 1893.
Liolophura hirtosus (Peron M.S.), Blainville, 1825.
Genus Onithochiton, Gray, 1847.
Onithochiton scholvieni, Thiele, 1910.

By Authority: Fred. Wm. Simpson, Government Printer, Perth.

7. CONTRIBUTIONS TO THE FAUNA OF ROTTNEST ISLAND.

No. III.

The Ants.

By
John Clark, F.L.S.
Entomologist, National Museum, Melbourne.

Communicated by L. Glauert.

(*Read 14th August*, 1928. *Published 22nd April*, 1929.)

The list given below is compiled from two lots of ants captured by Mr. W. H. Mathews (1922) and Mr. L. Glauert (1927). Four species were taken by Mr. Mathews, one of which proved to be new, the balance being added by Mr. Glauert. Only one is known to be confined to the Island, the others belonging to more or less widely distributed species. With the exception of *Rhytidoponera levior* the females of all the species are capable of flying, or of being carried by winds from the mainland to the Island. No doubt further exploration will bring to light additional species particularly when the roots and stems of the various trees and plants have been examined for the small and obscure forms found in these situations.

Family FORMICIDAE.
Subfamily PONERINAE.

Myrmecia infima. Forel,

Myrmecia picta, Smith; var. *infima*, Forel.
Ann. Soc. Ent. Belg. 44, p. 54, 1900.

This species is found along the coast from Geraldton to Albany. It is one of the smallest of the genus and very close to *M. nigra*, Forel, from which it can be distinguished by its yellowish antennae and legs. Although described as a variety of *M. picta* it has no connection with that species.

Rhytidoponera punctata, Smith, var. **levior,** Crawley.
Ann. Mag. Nat. Hist. (9), 16, p. 581, 1925.

This ant has so far been found only on the Island. It is much like *R. punctata* but the punctures are larger and more scattered giving it a more shiny appearance. *R. punctata* is widely distributed in Western Australia.

Euponera (Brachyponera) Lutea, Mayr.
Verh. Zool-bot. Ges. Wien. 12, p. 721, 1862.

One of the most widely distributed ants in Australia. It lives in small colonies under logs and stones but is also found nesting at the roots of trees and plants. The worker is yellowish or reddish in colour.

Subfamily MYRMICINAE.

Pheidole Hartmeyeri, Forel.
Fauna Sudwest Aust. 1, p. 280, 1907.

Originally found at Fremantle; several examples were taken by Mr. Glauert on the Island. It does not appear too common anywhere.

Crematogaster Laeviceps, Smith, var. **Chasei**, Forel.

Rev. Suiss Zool. 10, p. 413, 1902.

Originally described from Perth this form is widely distributed in South-West Australia.

Crematogaster Sp.

Several examples of males and females of an undetermined species were found flying to lights by Mr. Mathews. They appear to belong to *C. rufotestaceus*, Mayr.

Subfamily DOLICHODERINAE.

Iridomyrmex Rufoniger, Lowne.

This species is widely distributed throughout Australia. The examples taken by Mr. Glauert are not quite typical but are too close to separate at present.

Subfamily FORMICINAE.

Camponotus (Tanaemyrmex) Testaceus, Smith.

Cat. Hym. Brit. Mus. 6, p. 39, 1858.

A common and widely distributed species in Western Australia.

Camponotus (Myrmophyma) Walkeri, Forel.

Ann. Soc. Ent. Belg. 37, p. 454, 1893.

A widely distributed species originally described from N.W. Australia. It has previously been found at Perth and Fremantle.

By Authority: Fred. Wm. Simpson, Government Printer, Perth.

8. OBSERVATIONS ON THE LOAD CARRIED BY THE SWAN RIVER DURING THE 1926 FLOOD.

(With One Plate VIII.)

By

K. J. Finucane, B.Sc. and F. G. Forman, B.Sc.

(*Read 13th November*, 1928. *Published 22nd April*, 1929.)

The following paper is presented in the hope that it may give some idea of the order of magnitude of the transporting work done by a river such as the Swan, during periods of exceptionally heavy rainfall. The actual figures obtained are, of course, only approximate, and no pretension to accuracy is made. We are much indebted to Associate-Professor Clarke and Miss L. V. Hosking for criticism and advice in the course of preparing the paper for publication, and to the Perth Branch of the Commonwealth Weather Bureau for information supplied regrading the rainfall.

The most severe flood experienced in the South-Western Districts of Western Australia since the early nineties was that lasting from the 19th to the 26th of July, 1926.* The coastal areas extending for roughly one hundred miles both north and south of Perth were subjected to considerable damage consequent upon the rise and overflow of the more important rivers. In many places the Swan River overflowed its banks and many of the residential areas near Perth were either wholly or partly inundated. In the higher reaches of the river much damage was done to small orchards situated along the inner banks. At Fremantle the washing away of the northern abutment of the railway bridge, causing the collapse of the two northern spans some few minutes after the passage of a train, was an event which helped to impress people with the unusual severity of the conditions.

The area drained by the Swan River, and its tributaries the Helena and the Canning, may be divided into two sections, rather sharply separated by the Darling Fault Scarp, namely :—

(1) The Darling Peneplain which rises about 950 feet above sea level, and is dissected near its western edge by youthful river valleys.

(2) The Swan Coastal Plain in which the valleys are mature.

The average annual rainfall in the area concerned is about thirty-five inches, most of it falling between the months of April and September. During that time the rivers east of the Darling Fault Scarp, attain their maximum. In the summer months, October to March, the rainfall is very small : the rivers east of the escarpment then become at most, slowly moving streams which are clear and carry little, if any, sediment. Most of the rivers cease to flow altogether.

* After this paper was read Mr. W. Catton Grasby kindly supplied the following note :—"I can find no definite records of high floods in the Swan ; but the oldest residents agree that the highest flood since settlement occurred in 1872. After that there appears to have been a long period without very heavy floods. Mr. C. W. Harper tells me that there was a very high flood in 1904, and that it was considered to be the highest after 1872 to that date. Since that year floods have been common, the highest being in 1926, which was certainly higher than that of 1904, and old residents believe it to be the highest since 1872."

Flowing west and leaving the Darling Fault Scarp the rivers enter the Swan Coastal Plain, where they are broad, clear and practically without current, most of the water being in fact sea water. The Swan and Helena rivers join just below Guildford and thence form the drowned channel of the Swan River, which extends roughly from Perth to Fremantle and whose widest portion, Melville Water, is at the junction with the Canning River. Between Perth and Fremantle there is a comparatively narrow channel ranging in depth from ten to thirty feet, which is nearly everywhere flanked by extensive mud banks and sand spits, over which in normal seasons the depth of water is between six feet and a few inches. In winter the clear salt sea water is discoloured by muddy water flowing in from the higher reaches. This discoloration often reaches the river mouth but rarely extends more than a mile beyond it. Much of the sediment, carried in ordinary winter months, must, therefore, be deposited in the river itself and is no doubt responsible for many of the mud banks and sand spits.

During the 1926 flood a strong muddy stream flowed consistently seawards, discoloring the sea for a considerable area around the mouth. The unusually muddy nature of the river water, and the apparent broad zone over which the sediment was being deposited, suggested the probability that exceptional climatic conditions such as these were responsible for the greater part of the physiographic work done in this portion of the State, and that this was rather a unique opportunity for ascertaining the amount of material carried under such circumstances. A glance at the attached table, showing the rainfall for July and also the yearly rainfall for the years 1917 to 1926, will give some idea of the exceptional conditions. It will also be noticed that from the 18th to the 22nd of July, the rainfall at Perth, Mundaring and Chidlows was roughly an inch a day.

ANNUAL AND JULY RAINFALL AT SEVEN STATIONS IN THE SWAN BASIN FOR THE YEARS 1917 TO 1926.

		1917.	1918.	1919.	1920.	1921.	1922.	1923.	1924.	1925.	1926.	Average.	No. of years Record.
Perth ...	Year	4,564	3,958	3,066	4,035	4,109	3,186	4,447	3,379	3,141	4,922	3,437	52
	July	1,129	337	698	586	739	741	458	379	689	1,228	656	
Mundaring ...	Year	5,879	4,711	3,461	4,664	4,283	4,021	5,696	4,188	3,481	6,802	4,556	17
	July	1,389	320	722	694	849	1,084	575	620	842	1,667	879	
Chidlows ...	Year	5,511	3,723	2,931	3,453	3,409	3,436	5,281	3,738	3,207	5,816	3,676	20
	July	1,568	249	592	538	633	955	575	572	734	1,698	730	
Toodyay ...	Year	3,610	2,625	1,860	2,281	2,242	1,793	2,758	1,818	2,054	2,902	2,134	47
	July	1,012	175	460	319	374	672	297	268	403	825	428	
Northam ...	Year	2,776	2,000	1,399	1,937	1,991	1,718	2,314	1,377	1,797	2,267	1,710	46
	July	776	117	351	262	266	540	215	214	244	647	339	
York ...	Year	2,656	2,068	1,440	1,797	2,030	1,520	2,222	1,340	1,665	2,459	1,771	50
	July	672	109	295	268	315	468	169	208	241	830	335	
Beverley ...	Year	2,192	2,063	1,549	1,602	1,924	1,619	2,165	1,479	1,451	2,240	1,693	41
	July	535	126	294	219	355	511	177	231	254	651	324	

DAILY RAINFALL AT SEVEN STATIONS IN THE SWAN BASIN FOR THE PERIOD 16TH TO THE 31ST JULY, 1926.

(Falls for 24 hours ended at 8 a.m. on date against which they are entered.)

July, 1926	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Perth ...	76	28	102	111	17	89	11	13	..	..	9	5	18	8	90	12
Mundaring	1	15	220		1	150	62	..	..	...	122	24	74	20	140	25
Chidlows	67	26	81	183	240	172	8	7	..		102	17	81	1	60	18
Toodyay	19	11	42	45	118	62	1	5	..	..	27	.	50	2	75	10
Northam...	24	17	27	20	21	57	44	...	..	...	69	.	16	5	52	8
York ...	20	14	44	55	200	55	12	2	..	..	18	3	14	10	7	3
Beverley .	28	8	23	28	177	65	15	4			17	4	6	8	28	2

In order to ascertain the load carried by the river, samples of the flood waters were taken at various points which are shown on the accompanying map. At the same time the velocity of the current at these points was determined by timing over a known distance a wood float thrown into the stream. The flood level was marked on some convenient object. By evaporation the load in suspension and solution per 100 c.c. was calculated for each sample. No estimate of floating matter or material rolled along the river bed could be made. Where it was possible to obtain cross sections of the river, the volume of water flowing at flood level was determined for the period 19th to 20th July. Knowing the volume and the load in suspension and solution per 100 c.c. it was possible to calculate the load carried during the week. In two places only could we obtain the volume: (a) at the Fremantle Traffic Bridge, (b) at a point on the Helena River, just below its junction with Piesse Brook, where samples were taken at two points about five chains apart and the rate of flow and cross section were determined for each point.

STATEMENT OF DATA FOR CALCULATION OF TOTAL LOAD OF SWAN AND HELENA RIVERS DURING THE PERIOD 19TH–26TH JULY, 1926.

Locality	Samples.	Sediment gms. per 100 c.c.	Velocity feet per sec.	Area of cross sect. square ft.	19th–26th July, 1926	
					Vol. cu. ft.	Total Load. Tons.
Fremantle Traffic Bridge	No. 6	·3004	13·7	6,117	50,500,000,000	863,000
Helena River ..	No. 1	·0277	3·4	596	1,250,000,000	7,550
Do. ...	No. 2	·0152	6·2	348		

With the samples taken at the Helena River the calculated volumes were, No. 1 : 2,169 cubic feet per second ; No. 2 : 2,029 cubic feet per second. These values being fairly close show that a fair approximation to the true rate of flow was obtained considering the roughness of the method. For the purpose of the calculation of the Helena load the average value of samples No. 1 and No. 2 was taken. Where it was possible samples were taken in duplicate and sometimes in triplicate, the values given for the load in grammes per 100 c.c. being the average values obtained, the total load for the Swan and the Helena was then calculated in tons.

In making the above calculations it was necessary to assume, that the velocity of the stream was constant throughout the week, that the flood level remained constant, and also that the load itself was constant.

In addition to the above, three further samples were taken. :—
No. 3 at a point in the Swan above the Swan-Helena junction.
No. 4 at the Perth Causeway.
No. 5 in the deep water channel at Crawley.

At these points it was impossible to obtain cross sections but a comparison of the load per 100 c.c. of the six samples is interesting.

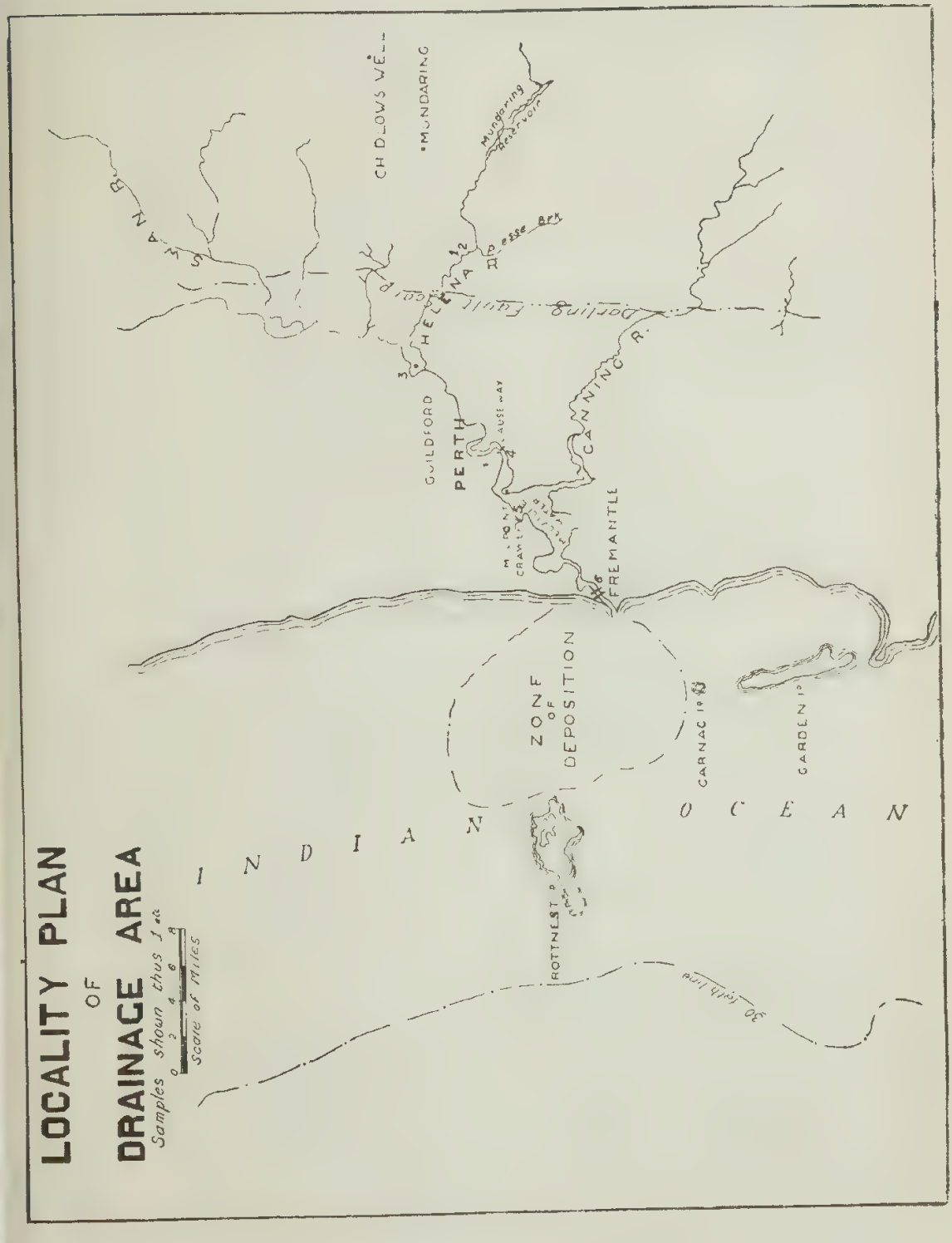
CALCULATED LOAD PER 100 C.C. IN PORTIONS OF THE SWAN AND HELENA RIVERS DURING THE PERIOD 19TH–26TH JULY, 1926.

Locality.	Mark on Map.	Number of Samples taken.	Average Value of Load in Grammes per 100 c.c.
Helena River	1 and 2	4	·0215
Swan	3	1	·1156
Causeway	4	2	·0798
Crawley Bay	5	3	·0982
Fremantle	6	3	·3004

From the above table it will be apparent that above its junction with the Helena, the Swan had a greater load per 100 c.c. than it had at the Causeway (c.f. samples No. 3 and No. 4), hence it appears that the Helena acted as a diluent. The relatively small amount of sediment carried by the Helena (samples No. 1 and No. 2) is explained by the filtering effect of the artificially drowned part of the Helena Valley at Mundaring Reservoir. Between the Causeway and Crawley the load increased, this may have been due to mud swept off the many banks existing between these localities. At Fremantle the load was three times that at Crawley, thus indicating that between these points much material had been swept from the mud banks and sand spits, and had been carried sea-wards. Owing to lack of facilities in the short period of duration of the flood, no samples were obtained from the Canning River and hence its effect on the Swan Load could not be determined.

Although the currents in the river channel kept the Fremantle Harbour effectively scoured, it was evident from the appearance of the sea off Fremantle, that on contact with the salt sea water, and with the lessening velocity of the freshwater stream, much of the sediment was deposited within ten miles of the river mouth. The zone over which the greater portion of the sediment appeared to have been deposited was judged roughly by the discoloration of the sea water, is shown on Plate VIII. and no doubt much of the finer sediment would be more widely spread, possibly reaching beyond the thirty fathom line.

PLATE VIII.



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9. CONTRIBUTIONS FROM THE DEPARTMENT OF BIOLOGY, UNIVERSITY OF WESTERN AUSTRALIA.

No. 13.

Records of Cladocera (Crustacea) from the South-West Province of Australia.

(With one Plate IX.)

By
D. L. Serventy.

(*Read* 13*th November*, 1928. *Published* 22*nd April*, 1929.)

With the exception of a single species *Moina flexuosa*, Sars described from Roebourne, the Western Australian fresh-water Cladocerans have up to the present time remained quite unknown. Since the Rev. R. L. King commenced the study of the Australian forms with the description of a number of New South Wales Cladocerans in the Proceedings of the Royal Society of Van Diemen's Land, 1853, the Eastern Australian members of the group have received the attention in turn of the late Professors J. D. Dana and G. O. Sars, the late Geoffrey Smith, and Miss Marguerite Henry, with the result that the total number of species was raised to 73, made up as follows: Sididae, 2 species; Daphnidae, 23; Macrothricidae, 7; Bosminidae, 4; Chydoridae, 37. Contributions to the geographical distribution of the group were also made by J. F. Haase, G. I. Playfair and J. Searle, and a valuable monograph of the species occurring in New South Wales, with lists of all the Australian forms, was published by Miss Henry in 1922.

The several memoirs of the late G. O. Sars, which are notable contributions to the study of the Australian Cladocerans were for the most part based on material hatched out in aquaria prepared with dried mud sent to him in Norway by Australian zoologists. These contributors included the late O. A. Sayce and T. Whitelegge, and J. Searle, and in New Zealand the Hon. G. M. Thomson and Professor C. Chilton.

In the present paper is recorded the occurrence of five species of the family Daphnidae from the South-West of this State. A new species is described and referred to the genus *Daphniopsis* of Sars, known heretofore only from Asia and Kerguelen Island in the Sub-Antarctic.

Most of the collecting for the purpose of the paper was made in the pools and swamps in the clays at Cannington during 1926 and 1927, and collecting trips have been made to Jandakot and Welshpool. Tubes of preserved material have also been received from Messrs. L. Glauert (Rottnest), W. H. Mathews (Rottnest and Bunbury) and D. C. Swan (Welshpool). My thanks are due to these friends for their interest, and also to Miss Henry (now Mrs. A. G. S. Cooper), of Sydney, for much generous advice and assistance, to Mr. J. Searle of Melbourne, for specimens and papers, to the late Professor G. O. Sars doyen of modern carcinologists for a set of some of his papers, to Mr. Glauert again for assistance with literature and to Mr. C. A. Gardiner for the production of the accompanying plate from my camera-lucida drawings.

Class CRUSTACEA.

Sub-class BRANCHIOPODA.

Order **CLADOCERA.**

Family DAPHNIDAE.

Genus **DAPHNIA**, O. F. Muller.

Daphnia Thomsoni, Sars.

Daphnia similis, G. M. Thomson (not Claus).
Daphnia thomsoni, G. O. Sars, Contributions to the knowledge of the Freshwater Entomostraca of New Zealand, *Christ. Vid. Selsk. Skrifter f.* 1894, *p.* 5, *pl. i.*

This species was originally described in New Zealand as *Daphnia similis* by the Hon. G. M. Thomson and was renamed *D. thomsoni* by the late Professor G. O. Sars owing to the *D. similis* of Claus an Asiatic species having priority to the name. In 1895 Sars found it to occur in South Africa, he having reared it in aquaria from mud obtained at Knysna, in Cape Province. It is figured in his Freshwater Entomostraca of Cape Province. (9).

The present record appears to be the first for Australia. Professor Chilton's remark that *D. thomsoni* is known to occur in Australia (2, p. 482) may be attributed perhaps to his sharing the view of Dr. J. Richard that *D. thomsoni* is a variety of *D. carinata* the common Eastern States' form a view which is not entertained by other workers. (8).

The post-abdomen of this species has the posterior or dorsal margin clearly sinuate, and armed with 11 to 14 well-marked anal spines. The sinuosity of this margin distinguishes the species from the closely related *D. carinata*, King, and Sars remarks on the resemblance of *D. thomsoni* to the European and South African species, *D. magna*, Straus, in respect of this feature.

I found the form to be extremely abundant in an open lake like fresh water swamp on the Pipe Track, three miles to the south-east of the Cannington railway station. The colour of these animals was pale green. In 1927 hazel or light chestnut individuals were present in relatively enormous numbers in a small pond adjoining the swamp and containing water stained with decaying vegetation. The carapace varied to some extent imparting to some specimens an appearance of enlarged size. I also collected the species in Lake Yangebup, near Jandakot, and have detected it in collections from Bunbury (W. H. Mathews), Welshpool (D. C. Swan), and from Rottnest Island (L. Glauert), the last-named specimens being taken from a pool south of The Basin in September, 1927, whence also the *Daphniopsis* (*infra*) had been collected two years previously. Sufficient collecting has not yet been undertaken to state it as a fact, but it would appear that *D. thomsoni* is the common *Daphnia* of the South-West.

Daphnia Carinata, King.

Daphnia carinata, R. L. King. On some species of Daphniadae found in New South Wales. *Papers and Proceedings of the Royal Society of Van Diemen's Land*, *Vol.* II, *pl. II.* (1853), *p.* 246. G. O. Sars, Daphnia carinata King, and its Remarkable Varieties, *Arch. Math. og Naturvid. Bd. XXXIV., No.* 1 (1914).

Specimens of this common Eastern Australian *Daphnia* were taken by me in a small pool in the valley of the Irwin River near Nangetty Station, some 35 miles north-east of Dongarra, during Professor E. de C. Clarke and party's visit there in August of this year.

The specimens somewhat resemble King's variety *gravis*, as illustrated by Sars (8), but do not reach the maximum size of 5 mm. which is given for that variety, the Nangetty examples measuring up to 4·1 mm. The frontal edge of the head is evenly curved as in Sars's variety *intermedia*, the tip of the rostrum projecting as a hook. The posterior spine is slender and markedly upcurved. The ventral margin of the shell is roundly curved. Nine to about fourteen anal denticles are borne on the post-abdomen. Both ephippia

and parthenogenetical females were present, the individuals varying considerably in size.

Genus **DAPHNIOPSIS**, Sars, 1903.

Of this interesting genus only two species have hitherto been recognised, and a third is now described. It was erected by Sars in 1903 to take a new species, *Daphniopsis tibetana*, collected in Toso Nor, Tibet, and in the North-West of Mongolia, which he considered to exhibit characters intermediate between *Daphnia* and *Simosa*. It resembled *Daphnia* in the shape of the ventral part of the head and the structure of the antennulae and antennae, and was like *Simosa* in the shape of the fornix and in the absence of either a dorsal carina or a posterior spine. Only parthenogenetical females were examined.

In 1911 F. E. Ruhe, working on the freshwater crustacea collected by the German South Polar Expedition of 1901-1903, described a second species of *Daphniopsis* from Kerguelen Island. The animal was named *D. studeri* and was stated to be identical with a species described by T. Studer from Kerguelen Island in 1878 (Uber eine Fauna von Susswassercrustaceen in Kerguelensland. *Arch. f. Naturgesch. Jahrg.* 44) as *Simocephalus intermedius*, which name was invalidated through the Law of Priority. After a detailed morphological examination of *D. studeri*, Ruhe stated that the resemblances of the genus *Daphniopsis* to *Simosa* were entirely superficial and that its true affinities lay with *Daphnia*. From evidence adduced particularly from a study of the structure of the legs, he claimed that Sars's view that *Daphniopsis* occupied an intermediate position between *Simosa* and *Daphnia* could not be sustained.

"I come to the conclusion," he wrote, "that *Daphniopsis* is no phylogenetic transitional form between *Daphnia* and *Simosa*, but a genus which is united in the most intimate manner to *Daphnia*" (translation). He concluded that of the two existing species *Daphniopsis tibetana* appeared to be an older form because of the *Daphnia*-like type of the ventral contour of the head and rostrum, and of the abdominal appendages, and that *D. studeri* might have been derived from it.

The species described hereunder and named *Daphniopsis pusilla*, bears resemblances to both of the existing species but is quite distinct from either.

Daphniopsis Pusilla, sp., nov.

Description. Ephippial female: Carapace, seen laterally, ovoid, robust, with the greatest width somewhat posterior to the minor axis. Head defined from the carapace dorsally by a well marked depression. Dorsal margin rounded, ocular region protuberant with a concavity both above and below the eye. Rostrum prominent, somewhat deflexed. Fornix evenly curved and extending to the ocular region. Ephippium boldly curved and from its posterior extremity it arches with a slight concavity to the obtuse but well marked posterior protuberance, thence arching convexly to a more or less well-defined infero-posteral angle. Free edges of valves smooth, surface of shell marked with quadrangular, pentagonal and hexagonal reticulations. Eye large, with crystalline bodies fairly well indicated. Ocellus punctate, occurring midway between the eye and the base of the labrum. Antennulae clearly projecting beyond the rostrum. Post-abdomen narrowly conical, with posterior margin evenly convex. Apical claws of moderate size, evenly curved and each armed with a row of fine spinules. Anal spines very small and about twelve in number. The dorsal processes are not well-marked in the preserved specimens and they are evident only as three conical bulges. Hepatic caeca prominent, coiled.

Male. Much smaller than the ephippial female, and more slender and elongated. Carapace, seen laterally, of narrow oblong form. Dorsal margin curved but almost straight. Posterior protuberance well-marked but infero-posteral angle absent. Head distinctly divided from carapace and not nearly so procumbent as in the female. Eye large. Antennulae, as is usually the case, elongated, each with a terminal flagellum longer than the base of the antennule. First pair of legs terminating in long setae. The post-abdomen like that of the female in form, but narrower and with posterior margin nearly straight.

Colour (in spirit). Dark brown, translucent. Ephippium black, some specimens showing a brown zoning.

Length. Female, 1·9 mm.; male, 1·25 mm.

Locality. Rottnest Island (W. H. Mathews, November, 1925).

Affinities. The present form differs from the type species of the genus *D. tibetana*, in a number of features. It is difficult to compare the general form of ephippial with parthenogenetical individuals, and the more vaulted appearance of the dorsal margin of the carapace of *Daphniopsis pusilla* is no doubt due to the outbulging of the ephippium. The posterior margin of the ventral edge of the carapace is more fully curved and there is a fairly distinct infero posteral angle which is absent in *D. tibetana*. The general outline of the carapace varies somewhat and I have broadly ovoid specimens, with extremely vaulted ephippia, recalling members of the genus *Moina* in appearance. The rostrum is not sharply pointed downward as in *D. tibetana*, but is rather obtuse. Though generally evenly rounded, the posterior margin of the post abdomen is sometimes found with a more or less distinct sinus. The anal spines, usually 12 in number, are about equal in size, and in some individuals may be differentiated into a posterior (distal) series of eight small spines and an anterior set of four larger ones divided off from the former by a small space. The apical claws differ in being denticulated. Finally *D. tibetana* is larger, though evidence on this point is inconclusive as ephippial females are normally inferior in size to parthenogenetical individuals.

In some of the characters in which *D. pusilla* differs from *D. tibetana* it shows agreement with *D. studeri*. Both of the southern species possess the blunt rostrum somewhat resembling that of *Simosa*, but the likeness is rather less close in the case of *D. pusilla*. The resemblances extend to the general shape of the post abdomen, and the denticulations of the apical claws. *D. pusilla* differs, however, in the possession of only one ephippial egg (there are two in *D. studeri*), in the more vaulted appearance of the dorsal margin of the carapace, in the smooth edges to the carapace, and in the lesser number of anal spines of which there are about 20 in *D. studeri*. Moreover there is no suggestion in any of the females of *D. pusilla* examined, or in the males, of the production of the dorsal protuberance into a small spine, which is the case in young females and males of *D. studeri*. The male of *D. pusilla* differs from the male of *D. studeri* in the fact that the head is extended, whilst in the latter species the head appears to be almost as procumbent as in the female. *D. pusilla* is slightly smaller than *D. studeri*, the female of which measures 2·1 to 2·35 mm., and the male 1·37 to 1·74 mm.

The difference in the number of ephippial eggs in the two forms is interesting. *D. tibetana* cannot be compared in respect of this feature as no ephippial females have been described. Two ephippial eggs are characteristic of the genus *Daphnia*, and one of *Simosa*.

The credit for the discovery of this exceptionally interesting form lies with Mr. W. H. Mathews, who took a large gathering of specimens in a pool in Rottnest Island during November, 1925. Ephippial females alone appeared to be present of that sex, with large numbers of males. The pool, which dries up in the summer, is located at the north-eastern end of the island, south of The Basin and just north of the series of salt lakes. The water, though not fresh, is potable but noticeably mineralised.

Distribution. The presence of a species of *Daphniopsis* in this State is a matter of considerable interest, though what light its occurrence may shed on problems of zoogeography cannot in the present state of knowledge of the distribution of the genus be properly appreciated.

The negative evidence afforded by its extreme rarity in collections suggests that the genus may not be widely ranging and therefore that it may be of more interest from the zoogeographical point of view than the majority of Cladocera.

Considering first the case of *Daphniopsis tibetana* and *D. pusilla* one might be tempted to ascribe to migratory wading birds an explanation of the discontinuous range of the genus. The possibility of eggs of the minute crustacea as well as of other forms of life, being transported from place to place in pellets of mud attached to the feet of Limicoline birds, or in their feathers, is an ever-present one. Several species of migratory wading birds breeding in Northern Asia winter in Australia, and incidentally, it may be stated are particularly abundant on the Rottnest Lakes.

The case of Kerguelen Island, however, raises an objection to the theory of transference thither of the *Daphniopsis* by birds, at least in recent times. This isolated island is visited by no migratory birds, save members of the petrel order, such as albatrosses, whose importance in the present connection may, I think, be discounted because their habits are pelagic except during the breeding season. The only wader is a resident *Chionis*. What the condition may have been in the past is unknown, but it would appear from the existing evidence that *D. studeri* is a long established resident on the island. This cannot be stated unequivocally of *D. pusilla*, but should such be the case one might venture a hypothesis accounting for the present distribution of the genus by regarding *D. pusilla* as an Antarctic element in the South-West fauna, separated from its congener in Kerguelen Island through the dismemberment of the so-called Gondwanaland (Australia, Antarctica, South Africa, South America and India). Birds might later have played a subsidiary part in affecting the intra-continental ranges of the members of the genus.*

Genus **SIMOSA**, Norman.

This genus was originally established under the name of *Simocephalus* by Schoedler in 1859 and was renamed *Simosa* by Canon A. M. Norman in 1903 owing to the earlier one being pre-occupied. The members of it are laboured swimmers, progressing frequently with the ventral surface uppermost. A characteristic habit of constantly flicking the post-abdomen aids a naked-eye identification of these forms in the field. They seem to favour weedy pools and swamps.

* The distribution of the genus *Daphniopsis* closely corresponds with that of the freshwater Copepoda of the family Boeckellidae, which has an extended circum-austral range in South America and the neighbouring islands, Australia and New Zealand. One species, *Pseudoboeckella brevicaudata* (Brady) occurs in Kerguelen Island, several species of *Boeckella* are found in Western Australia, and *Boeckella orientalis* (Sars) occurs in Mongolia. Other than the last-named, the members of this family do not extend beyond southern temperate and sub-antarctic latitudes, except at high levels in the Andes.

Simosa Australiensis, Dana.

Daphnia australiensis, Dana, Report of the United States Exploring Expedition, *Crustacea II.* 1853, *p.* 1271, *pl.* 89, *figs.* 4*a-e*.
Simocephalus australiensis, G. O. Sars, Additional Notes on Australian Cladocera, *Christ. Vid. Selsk. Forhandl. r.* 1888, *No.* 7, *p.* 15, *pl.* 2, *figs.* 1–5.

Professor Dana described this species from New South Wales, since when it has been collected widely in that State, also in Queensland and South Australia (Henry), Tasmania (G. W. Smith) and South Africa (Sars). Professor Sars considers it to be closely allied to the European species, *S. exspinosa* (de Geer), and suggests that its validity as a distinct species appears somewhat questionable. (9)

Specimens of this form occurred abundantly in the clay flats to the west of the Cannington railway station, being found in most of the holes and pools during the winter. These pools were clear of silt and debris and had comparatively little vegetation growing in them, the Cladocerans being bright green in colour. In December, 1927, I collected the species, in company with *S. gibbosa*, in a swamp in the sandy part of Welshpool, the water being full of vegetation, silty and of the usual dark colour. In this case the creatures were brown.

Simosa Gibbosa, Sars.

Simocephalus gibbosus, G. O. Sars. On Freshwater Entomostraca from the neighbourhood of Sydney, *Arch. Math. og Naturvid., Bd. XVIII., No.* 2.

This species was founded on material obtained at Centennial Park, Sydney, and the only other place in New South Wales where it has been collected is Botany (Henry). J. Searle has recorded it from Victoria and I have specimens from him. I collected the form in December, 1927, in the swamp at Welshpool mentioned under the previous species, it occurring rather sparingly in the shallows amongst the alga *Nitella*. The animals were brown in colour and were parthenogenetical females. My specimens have the apical claws not smooth but with the concave edge bordered with a row of very fine spinules.

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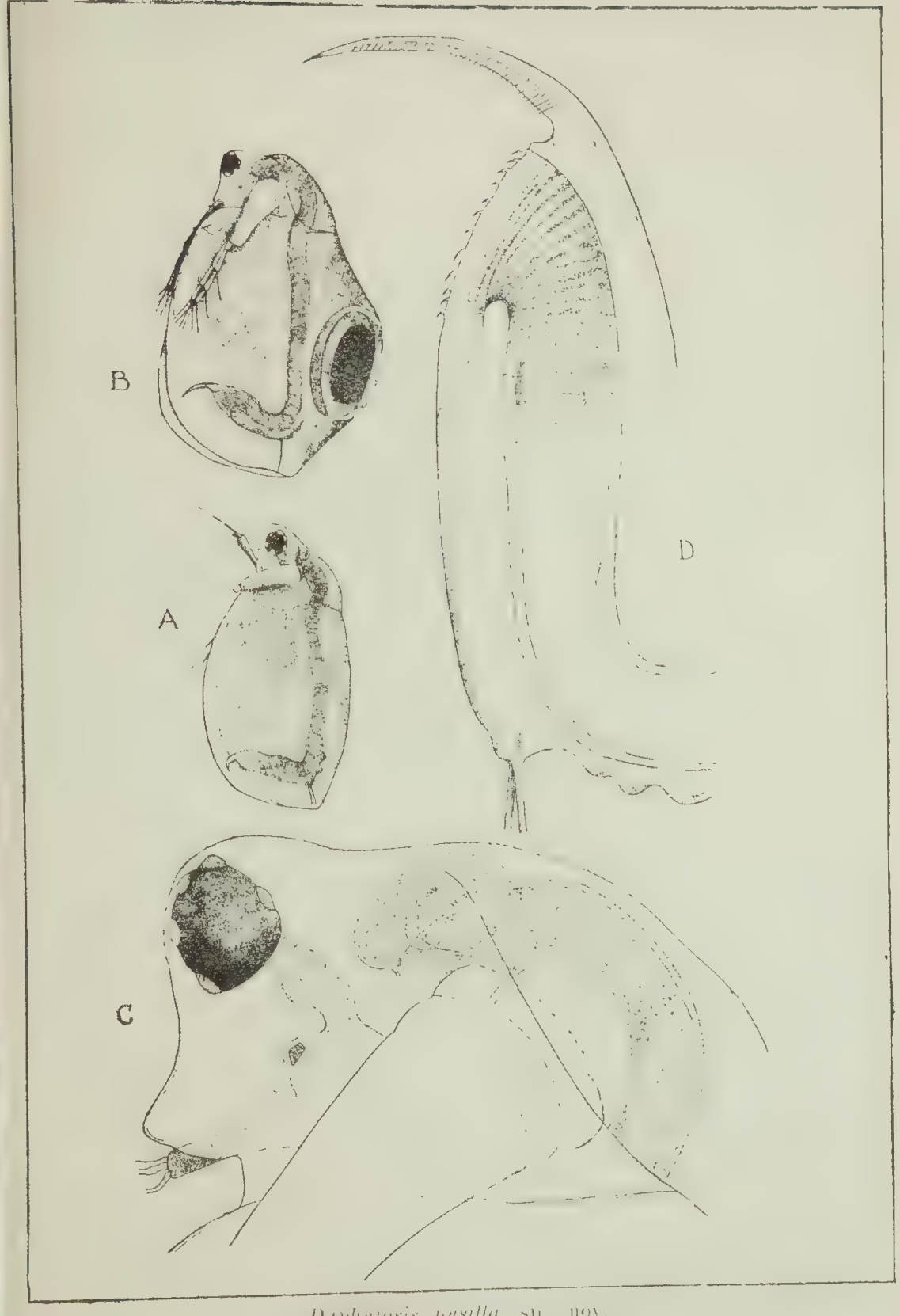
PLATE IX.



Daphniosis pusilla, sp., nov.

A, male: B, parthenogenetical female; C, head of female, enlarged; D, post-abdomen of female, enlarged.

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10. NOTE ON THE MORPHOLOGY AND ENDOTROPHIC MYCORRHIZA OF RHIZANTHELLA GARDNERI, ROGERS, AND CERTAIN OTHER WESTERN AUSTRALIAN ORCHIDS.

(With Three Plates, X., XI., XII.)

By

H. A. Pittman, B.Sc.Agr.

(*Read 11th December*, 1928. *Published 22nd April*, 1929.)

(1) **Rhizanthella Gardneri**, Rogers.

As has been shown by Rogers and Gardner in a recent number of the Proceedings of this Society,* the vegetative portions of this orchid are entirely subterranean. The plant is composed of a branching, roughly cylindrical, whitish rhizome, without roots. At the infrequent and faintly marked nodes occur short but wide-based white to dingy-coloured scales. The growing point produces a large bud which eventually expands into a bracteate capitulum of numerous small flowers. The lateral branches of the rhizome also each terminate in a flower-bud, but tend to be much narrower, more elongated and more thickly covered with bracts than the main or apical flowering stalk. The largest rhizome yet seen was about three inches long by one inch in diameter with lateral branches up to about four inches long by one quarter inch thick.

No portion of the plant has any chlorophyll development (or indeed the development of any pigment whatever with the exception of the capitulum bracts and the flowers themselves which may show a faint purplish colour especially on exposure to light). Supplies of organic matter must therefore be obtained in an already at least partially elaborated form. This is achieved through the agency of a mycorrhizal fungus on which the orchid must be considered to be parasitic.

Although devoid of roots the rhizome is fairly thickly covered towards the distal end with thick-based hairs which serve as a means of entry and of exit for the endotrophic mycorrhiza. Each of these hairs has a long, cylindrical, filamentous thin walled apical cell and a large, wart-like multicellular base. (Fig. 6, Plate XII.) The rhizome has no well marked protective or strengthening tissues externally but simply a thin-walled, small-celled epidermis. Immediately within the epidermis lies the ground tissue in which occur a variable number of small vascular bundles. In certain material examined the vasculars were arranged at wide intervals in a circle (Fig. 2, Plate X.), but in other rhizomes the vasculars were scattered about through the ground tissue in the normal manner characteristic of monocotyledonous stems. In the somewhat limited amount of material available for examination, no starch could be found within the tissues but considerable numbers of fat or oil drops were present in the peripheral cells occupied by the fungus.

With the exception of the epidermis, the outermost cells to a depth of about ten cell layers contained an endotrophic mycorrhiza. (Fig. 3, Plate XI.) In most of the material the fungus occurred all around the periphery of the rhizome, but in some cases the invaded tissue did not constitute a completely

* ROGERS, R. S. A new Genus of Australian Orchid. Jour. Roy. Society of Western Australia, Vol. XV., pp. 1-5, 2 Plates, 1928-29.

continuous band, being broken at intervals by small patches of uninfected cells. Infection appears to take place through the lumina of the filamentous apical cells of the thick-based hairs before mentioned. Not all of these apical cells contained the fungal filaments but in the majority a number of hyphae occurred. These ran more or less parallel to one another and branched infrequently. The hyphae in these cells had not become entangled, but had remained distinct from one another. In the cells at the base, however, they had become so much branched and so densely tangled together that the bases of the hairs appeared to the naked eye as minute black dots or sclerotia on the surface of the rhizome. (Fig. 6 Plate XII.) No case was seen where the fungus had entered or left the plant except through the apical cells of the thickbased hairs.

Both in the apical cells of the hairs and in the cells of the ground tissue the fungus was markedly septate Fig. 4, Plate XI.), and could be seen branching very obviously at right angles. In unstained sections the fungal hyphae and the amorphous masses into which they eventually degenerate had a golden to brown colour, and the general appearance of the hyphae strongly suggested a species of *Rhizoctonia*.

In the innermost two or three rows or so of invaded cells in the material examined, the fungal hyphae had become closely clumped together and had passed into an amorphous golden-brown deeply staining mass to which the enlarged and deeply staining nuclei of the host cells could often be seen closely applied. (Fig. 5, Plate XII.) The specimens examined had not flowered and in the majority of the infected cells the fungal hyphae were winding very much about one another, branching frequently at right angles and closely enclosing the disorganised host nuclei. The fungus was wholly intracellular and consequently no arbuscles or sporangioles were present. No vesicles or spore like bodies were observed within the host cells. Where the hyphae came into contact with the host walls in passing through the tissues they had commonly formed swollen appressorium-like structures, from each of which a very narrow peg-like process had grown out to penetrate the host wall. On the other side of the wall the hyphae had regained their normal dimensions (Fig. 5, Plate XII.)

Attempts were made on several occasions to isolate the mycorrhizal fungus and on each occasion a particular species of *Aspergillus* was obtained. The growth characters on culture media with the exception of the colour of the mycelium closely resembled the type of mycelium found in the orchid. Mature seeds or uninfected rhizomes of the higher plant were not available, however, for infection experiments, and the relation or otherwise of the isolated fungus to the mycorrhizal condition is not known. A very suitable staining combination for the study of the mycorrhiza of *Rhizanthella* is Night Blue or Cyanin followed by Acid Fuchsin after fixing in Flemming's weaker solution.

(2) Some Other Terrestrial Western Australian Orchids.

As a matter of interest and for purposes of comparison certain other Western Australian orchids were examined. These included *Caladenia flava* R.Br., *C. Patersoni* R.Br. var. *longicauda* (Lindl.). Rogers, *C. gemmata* Lindl., *C. sericea* Lindl., *Pterostylis turfosa* Endl., *Prasophyllum fimbria* Reichb., *Dicrys longifolia* R.Br., *Leptoceras rigricans*, R.Br., *Thelymitra crinita* Lindl. and *T. longifolia* Forst. All specimens were examined when in flower.

(a) **Caladenia** species.

As stated in Bentham's "*Flora Australiensis*" the Caladenias are terrestrial herbs with small tunicated underground tubers. Below the ground level the downward prolongation of the flowering axis can often be traced vertically to a depth of about three or four inches, at about which point one or more laterally-borne tubers are commonly found. These tubers on sectioning are found to show the scattered vascular arrangement and general structure typical of monocotyledonous stems. Beyond the point of attachment of these tubers the axis appears to lie more or less horizontally and often increases in diameter as it is traced backwards to a point where a further structure occurs which is apparently the original or parent tuber. In certain material of *C. Patersoni* var. *longicauda*, small roots arose from the point of attachment of the axis to the parent tuber. Apart from these small roots which may arise at the junction of the parent tuber and the axis of the new plant, no other roots seem to be formed.

It would be expected from the method of derivation of the main axis (arising as it does from a true stem-tuber) that the underground portion would have the structure of a stem. On sectioning, however, the anatomy is commonly found to be more like that of a root or at the least a much-modified stem. There is a thin-walled epidermis within which is a fairly extensive cortex region which is very obviously delimited from the vascular cylinder by an endodermis of one or more rows of cells (Fig. 1, Plate X.). The endodermal cells are made very obvious in either transverse or longitudinal section on account of the presence of large, branched, spiral thickenings. In the material of *C. Patersoni* var *longicauda* there was a four or more rowed endodermis; *C. gemmata* had two to three rows; *C. flava* had two rows, while *C. sericea* had one. (*C. flava* differed very markedly from the other species mentioned by having very large semicircular thickenings on the radial walls of the epidermal cells). In the material of *C. flava* the vascular cylinder had very much the structure of a woody dicotyledonous stem. There were some five or six separate vascular bundles arranged more or less in circular fashion around a well marked "pith." The xylem elements were large and thick-walled while the phloem tissues were small celled and thin walled, and arranged in much the same manner as in a woody dicotyledonous root or stem. In *C. sericea* the vasculars were much more scattered and had more the arrangement of a typical monocotyledonous stem than in *C. flava*.

The exterior of the underground stem in all the Caladenias examined showed numerous multicellular wart-like hairs very much like those met with in *Rhizanthella*. They had this difference, however, that instead of merely a single elongated apical cell to each protuberance (as in *Rhizanthella*) the majority had a *number* of long filamentous cells produced by the outward prolongation of as many terminal cells. (Fig. 1, Plate X.) These provided the sole means of entrance and of exit for the mycorrhizal fungus which occurred in the cells of the cortex. In all the material examined the fungus was in the amorphous condition in the whole of the cells occupied with the exception of those of the hairs. (Fig. 1, Plate X.). No fungus was found in the tubers.

A peculiar feature of the underground portions of the Caladenias examined is the possession of a continuous brown sheath formed from organic matter, interwoven apical cells of the wart-like hairs, fungal hyphae, sharp-pointed spiral rods and certain peculiar net-like thickenings which appear to originate in the swollen portion of the stem immediately in advance of the old parent tuber. The sheath is very absorbent of moisture and may serve

the purpose of keeping the underground parts of the plant moist during periods of comparative soil dryness. Although it is closely applied to the underground stem it is quite distinct from it, except in the lower regions which lie between the old and the new tubers. The sheath can be readily removed from the stem above the new tubers without causing any damage to the plant tissues except for the breaking of many of the filamentous cells of the thick-based hairs.

(b) **Pterostylis turfosa.** (Bird Orchid.)

The specimens of this orchid each had a small rounded tuber situated an inch or so below the ground level from which arose a vertical underground stem. The underground stem gave rise to a new tuber at approximately the level of the old one and bore a number of small horizontal lateral roots at various points between the tubers and the ground level. No fungus was found in the roots or tubers examined, but the underground stem contained an intracellular fungus in considerable quantity. The stem below the ground level has large wart-like multicellular hairs, each with a number of elongated apical cells as in the Caladenias. Numerous vascular bundles occurred irregularly scattered through the central portion of the stem. The fungus occurred intracellularly in the cortical region. Fungal hyphae passed down the apical cells of the wart like hairs into the soil.

(c) **Prasophyllum fimbria.**

Each specimen had a number of long, more or less, horizontal roots developed from the base of the flowering stem at the same region as the new tuber was produced. The new tuber was white, globular and comparatively smooth walled, while the old one was brown in colour, very hairy and fluted with a number of deep depressions. No fungus was found in the young or old tubers but a fungus occurred in the roots. Both young and old tubers contained abundant starch (staining red-brown with iodine) and possessed a well-defined stem structure. The roots showed a large-celled, thin walled epidermis, an extensive cortex and only a small vascular region. The endotrophic mycorrhiza was only present a short distance into the cortex in most cases but occasionally extended in patches to the boundary of the vascular cylinder. The root hairs were simple outgrowths of the epidermal cells and provided a means of invasion for the fungal symbiont.

(d) **Diuris longifolia.**

Each specimen had a number of long thin roots developed from the base of the flowering stem. It also bore long, white, fleshy tuberous roots. These tuberous roots showed no fungal inhabitant but mycorrhiza occurred in the narrower roots in great abundance. The tuberous roots were similar in structure to the smaller roots but had a much larger cortex. The root hairs were normal on both types, and in the case of the invaded roots provided a readily availed-of means of entrance for the associated fungal inhabitant. No tubers were seen.

(e) **Lyperanthus nigricans.**

Each specimen of *Lyperanthus nigricans* had a stout vertical underground stem with numerous elongated narrow roots coming off laterally. The roots examined contained a somewhat scanty amount of a fungal symbiont. The endodermis was very noticeable in the roots and was composed of very large, angular, thick-walled cells. The root hairs were normal and provided passage ways for the mycorrhiza. Sections of the underground stem showed no fungus.

(f) **Thelymitra crinita.**

This orchid produces a number of more or less closely whorled, brownish, fleshy roots and a large white sub-cylindrical or pyriform tuber in a position closely adjacent to that occupied by the old one. Microscopic examination of roots revealed the presence of intracellular endotrophic mycorrhiza in considerable abundance and extending in some cases into the region of the faintly-marked endodermis. The root hairs were normal and many contained the mycorrhizal filaments. No fungus was present in either the new or the old tubers. A peculiar feature of the tubers was the absence of vasculars from the bulk of the tissue. What vasculars did occur were very small, few-celled, and located in a circular fashion *in a single continuous ring of several rows of small more or less oblong or ovoid cells.* This ring completely surrounded a well-marked "pith." Outside the ring the parenchymatous cells in the young tubers were densely packed with starch (staining red-brown with iodine), but the cells of the "pith," were devoid of starch.

(g) **Thelymitra longifolia.**

Except for minor differences the anatomy and mycorrhiza of the roots, and the anatomy of the tubers of T. *longifolia* was as described above for *T. crinita.*

* * *

It is interesting to note that mycorrhiza was found in some portion of all the orchids examined, but never in the tubers or other vegetative propagating organs except in *Rhizanthella* (where a rhizome is the only vegetative structure produced). Moreover, it will be observed that in all cases the mycorrhiza was strictly intracellular, and in no single instance was the fungal inhabitant seen to enter or leave the plant infected except through the lumina of hairs produced either on the roots or on the stems. In *Rhizanthella, Caladenia* and *Pterostylis* special hair structures seem to have been evolved on the stems to ensure more adequate and certain invasion by the fungal inhabitants. *Rhizanthella* is an example of an orchid which is entirely dependant for its sustenance on the fungus with which its vegetative parts are intimately associated.

In conclusion it must be stated that this note does not pretend to have more than skimmed the surface of the subjects dealt with. A complete study of the morphology and mycorrhiza of any particular species mentioned above would take much more time than the writer has been able to give to the whole group listed. As regards the indigenous orchids of Western Australia the field is so far unexplored and much of intense interest awaits the future prospector. These lines will have served their purpose well if they simply bring to the notice of students of nature a field of research as yet untraversed and well worthy of close investigation.

My thanks are due to Mr. C. A. Gardner, Assistant Botanist, Department of Agriculture, for identification of the species examined, and to Mr W. M. Carne, President of this Society for provision of the material, kindly assistance in every way, and helpful criticism.

EXPLANATION OF PLATES.

PLATE X. *Fig.* 1: T.S. of underground portion of stem of *Caladenia flava* R. Br. X35. Note mycorrhiza in the amorphous condition in the cells of the cortex, but in the filamentous condition in the basal and apical cells of the wart like hairs. Note also the two-rowed endodermis with spiral thickenings. A, wart-like hair; B, apical cell containing fungal filaments; C, apical cell without fungal filaments.

Fig. 2: T.S. of rhizome of *Rhizanthella Gardneri*, Rogers. X6. Note vascular bundles arranged in a ring. Note also amorphous fungal masses in the cells around the peripheral region. A, wart-like hair with single long filamentous apical cell which provides a passage-way for the mycorrhiza in invading or leaving the host.

PLATE XI. *Fig.* 3: T.S. of rhizome of *Rhizanthella Gardneri*. X25. A, wart-like hair with broken filamentous apical cell containing fungal hyphae; B, region containing fungus in the filamentous condition; C, region containing fungus in the amorphous condition; D, vascular bundle.

Fig. 4: T.S. of rhizome of *R. Gardneri* showing septate fungal filaments in the single apical cell of a thick-based hair. X 100. (This hair has a longer base and a shorter apical cell than is usual.) A, fungal filaments in host cells closely surrounding the host nuclei.

PLATE XII. *Fig.* 5: T.S. of rhizome of *Rhizanthella Gardneri*. X 230. Note the much branched septate hyphae and the amorphous fungal masses. A, much enlarged deeply staining nucleus of host cell closely appressed to an amorphous fungal mass. The nucleolus is deeply stained. Stain: Night Blue and Acid Fuschin following Flemming's weaker fixative; B, Cell in which fungus is dominant. Note smallness and disorganisation of the host nucleus. C, Hypha passing through wall of host cell. Note peg-like process passing through the host wall.

Fig. 6: Complete thick-based hair of *R. Gardneri*, X50. Note fungal hyphae within the lumen of the filamentous apical cell. Note also denseness of the entangled hyphae in the multicellular base and at the tip of the apical cell.

All drawings were made with the aid of a camera lucida.

PLATE X.

Fig. 1. Transverse section of underground portion of stem of *Caladenia flava*. X 35.

Fig. 2. Transverse section of rhizome of *Blancheella Gunnii*. X 6.

PLATE XI.

Fig. 3. Transverse section of rhizome of *Rhizocalladia Gardneri*. X 25.

Fig. 4. T.S. of *R. Gardneri*, showing septate fungal filaments in apical cell of a thick-based hair. X 100.

PLATE XII.

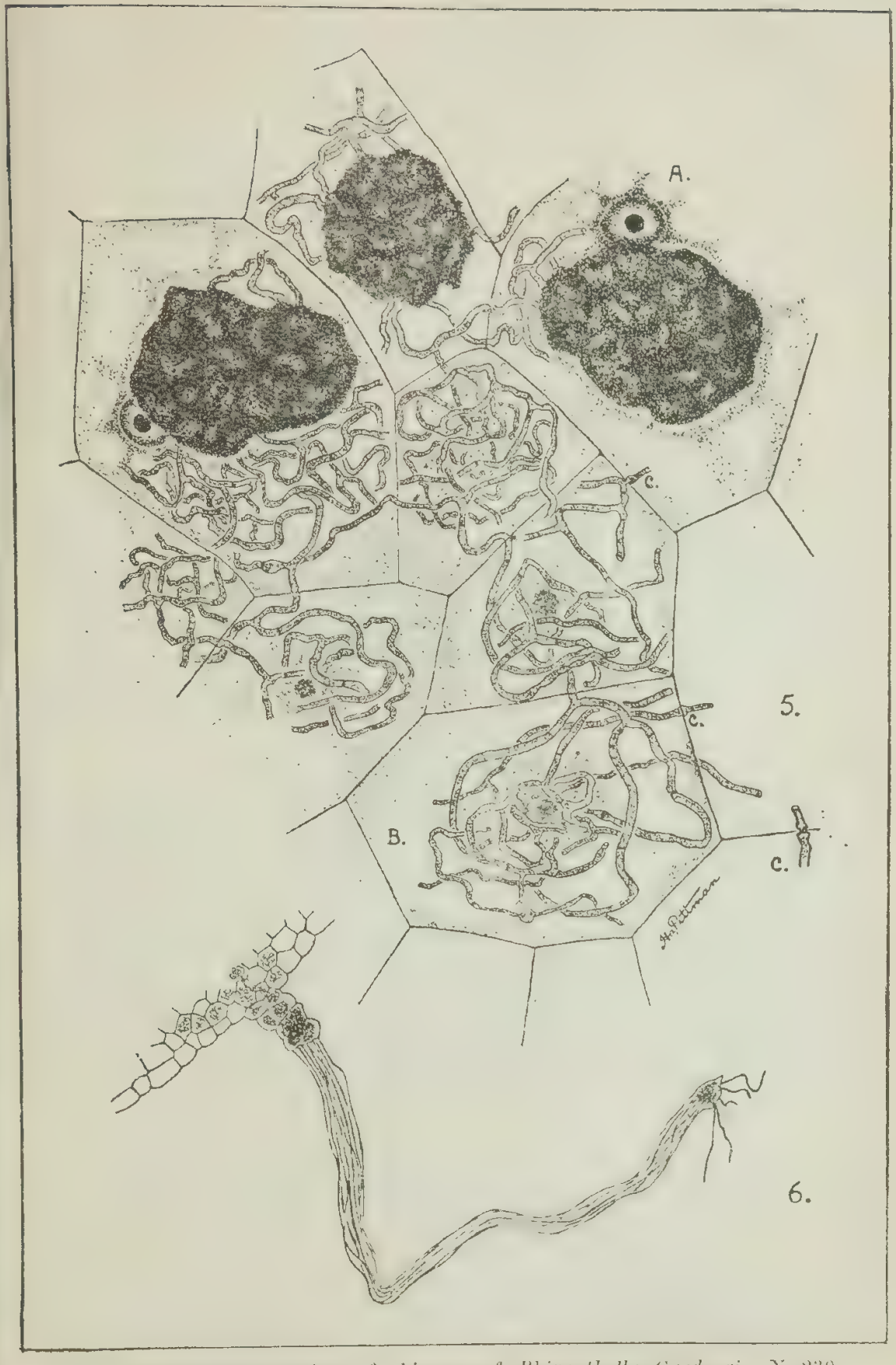


Fig. 5. Transverse section of rhizome of *Rhizanthella Gardneri*. X 230.

Fig. 6.—Complete thick based hair of *R. Gardneri*, showing numerous fungal filaments within it and also protruding into the soil. X 50.

By Authority: Fred. Wm. Simpson, Government Printer, Perth.

11. A NEW SPECIES OF PERSOONIA FROM WESTERN AUSTRALIA.

(With one Plate XIII.)

By

J. W. Audas and P. F. Morris, National Herbarium, Melbourne.

Communicated by C. A. Gardner.

(*Read 13th November*, 1928. *Published 22nd April*, 1929.)

The genus *Persoonia* was described by Dr. James Edward Smith, M.D., F.R.S., in the Transactions of the Linnaean Society, London, vol. iv., p. 215 (1798). It is a large genus, the species being nearly equally divided between Eastern and Western Australia, and with the exception of a single New Zealand species (P. Toru) is limited to Australia. It consists chiefly of shrubs or small trees, which differ considerably in size and in the shape of their leaves; the flowers are usually yellow or white, and very similar, and the fruits which are succulent, are generally known as "Geebungs," and hence the trees and shrubs themselves.

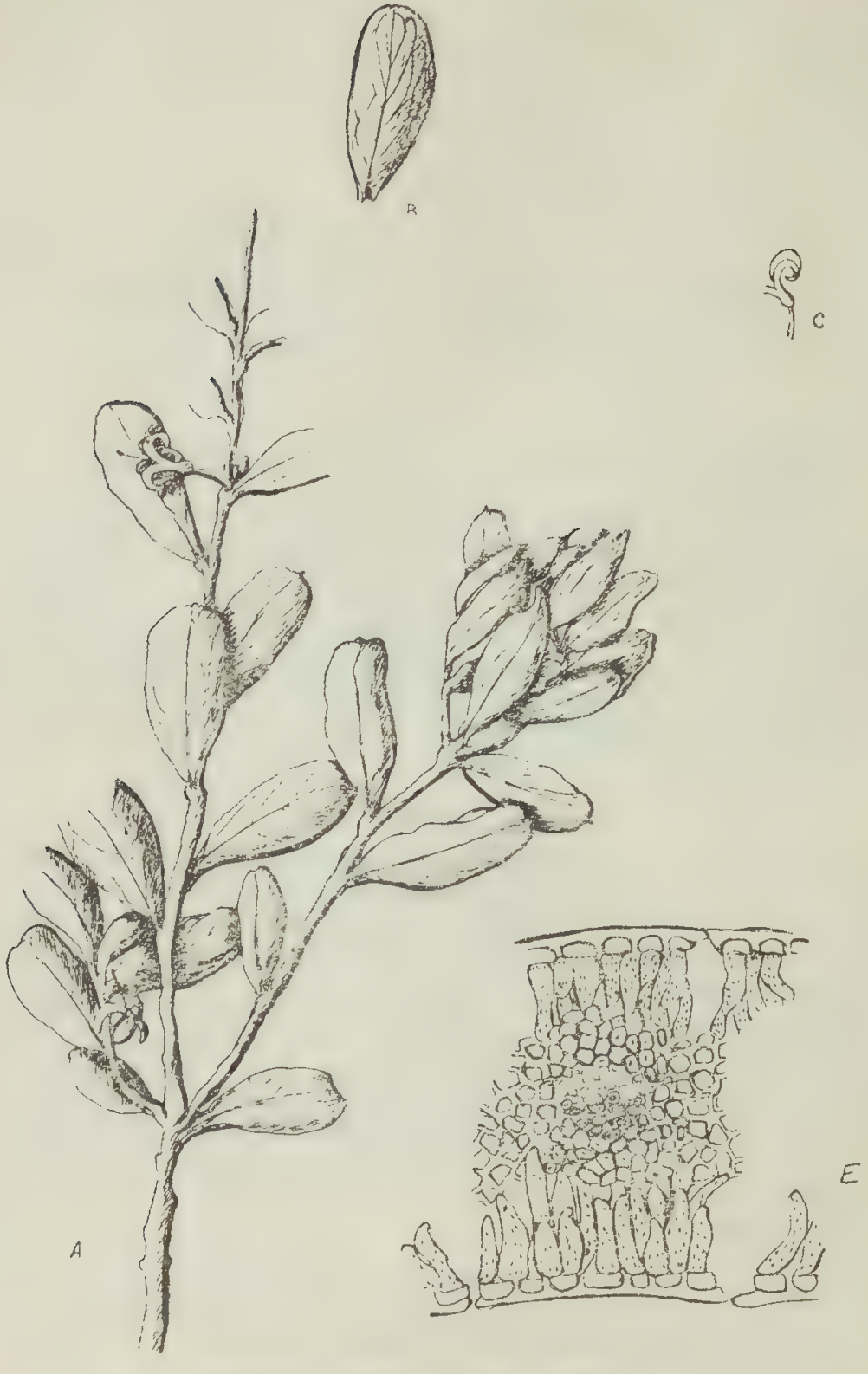
Persoonia coriacea, n. sp.

A shrub 3–4 ft. high, the older branches glabrous and mealy; the new wood of the branchlets salmon-coloured and clothed with hairs. Leaves alternate—a few almost opposite—obovate, shortly mucronate, 2–3 cm. long 1–1·5 cm. broad. Leaves on the young wood purplish-tomentose at the base with a few hairs sparsely distributed on the lower parts; on the old wood, glabrous, slightly glaucous, coriaceous, the margins distinct, venation, thick, midrib distinct on the young leaves, lateral veins arcuate, anastomosing. Pedicels hairy, solitary in the axils of the leaves, or with reduced or abortive floral leaves at the base. Perianth 5–6 lines long, ciliate at half-way up, then becoming slightly ciliate. Style slightly elongated beyond the anther cells with a terminal stigma. Anther-connective not produced beyond the cells. Ovary glabrous on a short glabrous stipes articulate above the base. Style elongated, stigma small.

Western Australia: Merredin, on sand plain which had apparently been burned off several years previously, destroying all the old shrubs. Max Koch, No. 3004, 30th November, 1923.

This species belongs to the Section *Amblyanthera* of Bentham. It has a similar appearance to *P. marginata*, a native to New South Wales, from which it differs in the shape of its leaves, pubescence of young foliage, and in having an entirely glabrous ovary.

PLATE XIII.



Persoonia coriacea, Audas and Morris.

A.—Small twig (natural size).
B.—Single leaf (natural size).
C.—Petal and Stamen (natural size).
D.—Gynaeceum (natural size).
E.—Transverse section through fragment of a leaf, showing a small vascular bundle cut across. Microscopic drawing, low power.

By Authority: Fred. Wm. Simpson, Government Printer, Perth.

12. THE BOTANICAL ACTIVITIES OF MAX KOCH.

By

J. W. Audas, F.L.S., F.R.M.S., National Herbarium, Melbourne.
Communicated by C. A. Gardner.

(*Read 13th November*, 1928. *Published 22nd April*, 1929.)

The late Max Koch, who died at Pemberton, Western Australia, on the 1st April, 1925, was well known as a botanical collector in Europe, America and Australia. He was born on 17th July, 1854, in Berlin, Germany, and at an early age entered a merchant's office as an apprentice. Office work, however, did not appeal to him, so that eventually he signed-on in Bremerhaven in October, 1877, on a Glasgow sailing ship, and came to Australia. Leaving the ship at Port Augusta, South Australia, in April, 1878, he went to work on wheat farms, and found this life very congenial. Later on he went to Mount Lyndhurst Sheep Station for a change: Here, in 1888, he married, and was employed as a boundary rider until 1901. During this year he left Australia and returned to Germany on a holiday trip. In 1904 he left South Australia and came to Western Australia, where he spent the remainder of his life. For the seventeen years subsequent to 1904 he was employed by Saw Milling companies in the South-West of Western Australia.

His botanical activities between the years 1908 and 1925 were considerable. Taking into consideration that all of this work was carried out in his very limited spare time, the performance is outstanding. The work, however, was a labour of love, and the incentive of increasing his income, and thus enabling him to keep a large family in comfortable circumstances, impelled Max Koch to turn every minute to the best use. He certainly had no idle moments. Apart from collecting herbarium specimens, he sold seeds of Australian plants to nurserymen and private persons in appreciable amounts. In the course of correspondence with me extending over many years, he mentioned that the late Mr. J. H. Maiden, Government Botanist, Sydney, had been his oldest correspondent. Mr. Maiden identified the greater part of his South Australian collections, and also a number of his Western Australian plants, among which several new species were traced, named and described. Ten sets of the Mount Lyndhurst plants were forwarded to Mr. Maiden, and were used for exchange with other countries to assist in the construction of the Sydney Herbarium. Mr. Maiden also purchased seeds and carpological specimens of all kinds, and purchased a full set of Western Australian plants and seeds.

In addition to the above the following Institutions and persons received specimens from Max Koch:-

Botanic Gardens, Adelaide	Seven sets of plants from Mt. Lyndhurst, and seeds, also two sets of W.A. plants.
Botanic Gardens, Melbourne	Seeds.
Department of Agriculture, Hobart	Full set of South Australian plants, and 100 specimens from Western Australia.

Botanic Gardens, Brisbane	400 sheets of Western Australian plants.
Department of Agriculture, Wellington, N.Z.	200 sheets of specimens.
Adelaide University	Full set of South Australian plants.
Department of Agriculture, Perth	South Australian and Cowcowing (W.A.) plants.
Perth Museum	Set of types of new species collected in W.A.
Royal Botanic Gardens, Edinburgh	Set of all specimens collected until 1914.
Botanisk e Have, Christiania	Set of S.A. and W.A. plants.
Bergens Museum, Norway	400 sets of W.A. plants and carpological specimens.
Museum d'Histoire Naturelle, Paris	Set of W.A. and S.A. plants.
Stadt Museum, Bremen	Full set of W.A. and S.A. plants.
Botanic Gardens, Berlin	Full set of S.A. plants, and seeds from W.A.
K.K. Hof. Museum, Vienna	Full set of S.A. plants, and seeds from W.A.
Botanic Gardens, Vienna	Western Australian seeds.
University of Toronto	Set of Western Australian specimens.
Gray Herbarium, Cambridge, U.S.A.	250 sheets of Western Australian plants.
Pringle Herbarium, Burlington, U.S.A.	400 „ „ „
University of Minnesota, U.S.A.	215 „ „ „
University of Nebraska, Lincoln, U.S.A	200 „ „ „
Botanic Gardens, St. Louis, U.S.A.	Set of Western Australian plants.
Arnold Arboretum, U.S.A....	100 sheets of woody plants.
Science and Arts Institution, Dublin	200 sheets of Western Australian plants.
Botanic Gardens, Ofen Pest, Hungary	100 sheets of South Australian plants.
Botanische Staats Institute, Hamburg	300 sheets of Western Australian plants.
Dr. L. Diels, Botanic Gardens, Berlin	300 „ „ „
Dr. Radlfoffer, Muchen	100 sheets of South Australian plants.
Dr. Goldschmidt, Essen ...	Bulbs of terrestrial orchids.

Localities where Mr. Koch collected in South Australia :—

	Species.
1896-1900—Village Well on Mt. Lyndhurst Station *via* Farina (Nos. 1 to 400)	400
1901—Near Port Pirie, South Australia (Nos. 401 to 600)	200
1902–1903—Near Adelaide, Mt. Lofty Ranges, Brighton, Cookes' Plains, Ninety-Mile Desert (Nos. 753 to 973)	220
Total	820

The material collected at Mt. Lyndhurst was taken in large quantities, also that from Port Pirie and near Adelaide to supply many subscribers.

Localities where Mr. Koch collected in Western Australia :—

		Species.
1904	June to November, Cowcowing district (Nos. 974 to 1292)	310
1905	January to November ; No. 2 Rabbit Fence, 50 miles east of Watheroo Railway Station (Nos. 1293 to 1385) .... about	100
	(A considerable number of specimens were later named among the Wooroloo plants.)	
1906–1908—	Wooroloo, also Darling Ranges (Nos. 1386 to 1851)	465
1908–1915—	Lowden, Preston Valley, also Donnybrook, Busselton, Kirup and Armadale (Nos. 1852 to 2222)	335
1913—	Kukerin, a few days only (Nos. 2175 to 2217)	40
1916–1923—	Pemberton, Big Brook, Jarnadup, Palgarup, Manjimup (Nos. 2224 to 2865)	460
1923–1924—	Merredin, Yerbillon, Hines' Hill (Nos. 2686 to 3035)	350
	Total	2,880

The following new species were collected by Mr. Koch near Village Well Mt. Lyndhurst Station, in South Australia :—

No. 300, *Myoporum refractum*, Maiden ; *Atriplex Kochiana*, Maiden. No. 332, *Zygophyllum hybridum*, Tate. No. 469, *Zygophyllum Kochii*, Tate ; *Corchorus longipes*, Tate ; *Minuriella annua*, Tate (referred to *Minuria annua*, Tate, by Professor A. J. Ewart) ; *Eriocaulon submersum*, Tate. No. 354, *Aizoon Kochii*, K. Wagner (published in *Annalen des* K.K. *Naturhistorischen Hof. Museum*. Nos. 347–348 *Podocoma nana*, Ewart & White -Total 9 species.

New species found in Western Australia, 1904 to 1923–24 :—

No. 1674, *Zygophyllum ovatum*, Ewart & White (since discovered in South Australia). No. 1217, *Trichinium* (*Ptilotus*) *eriotrichum*, W. V. Fitzg.) Ewart & White. No. 1273, *Kochia Massoni*, Ewart. No. 1051, *Salicornia Donaldsoni*, Ewart & White. No. 1969, *Stenopetalum album*, E. Pritzel. No. 2016, *Hibbertia Kochii*, Maiden & Betche. No. 1596, *Cryptandra apetala*, Ewart & White. No. 2409, *Choretrum pendulum*, Tovey & Morris. No. 1459, *Trachymene Kochii*, E. Pritzel. No. 1204, *Eremophila Kochii*, Ewart. No. 2244, *Bossiaea Laidlawiana*, Tovey & Morris. No. 1337, *Gastrolobium Laytoni*, Jean White. No. 1365, *Daviesia Grahami*, Ewart & White. No. 2041, *Daviesia costata*, Cheel. No. 1013, *Acacia Mackeyana*, Ewart & White. No. 1616, *Acacia Kochii* (W. V. Fitzgerald) Ewart & White. No. 998, *Acacia Ewartiana* (W. V. Fitzgerald) Jean White. No. 1341, *Acacia longiphyllodinea*, Maiden. No. 1289, *Acacia Beauverdiana*, Ewart & Sharman. Nos. 1025, 1039 and 1039a, *Acacia Coolgardiensis*, Maiden. No. 1030, *Acacia longispinea*, A. Morrison. No. 1233, *Chamaelaucium Hallii*, Ewart. No. 1230A. *Thryptomene Kochii*, E. Pritzel. No. 1021, *Baeckea Maideni*, Ewart & White No. 2539, *Kunzea sulphurea*, Tovey & Morris. No. 1334 *Bellida*

graminea, Ewart. No. 1509, *Podolepis Spenceri*, Ewart. No. 1196 *Angianthus axiliflorus* (W. V. Fitzgerald), Ewart & White. No. 1873, *Angianthus lanigerus*, Ewart & White. No. 1553, *Helipterum album*, Ewart. No. 1554, *Calocephalus Skeatsiana*, Ewart & White. No. 1239, *Scirpus Kochii*, Maiden & Betche; *Eucalyptus transcontinentalis*, Maiden—Total 33 species.

New varieties found in Western Australia:—

No. 1083—*Eriostemon tuberculosus*, F. v. M. var. *megaphyllus*, Ewart

No. 1229—*Baeckea crispiflora*, F. v. M. var. *tenuior*, Ewart.

No. 1001—*Eucalyptus oleosa*, F. v. M. var. *glabra*, Maiden.

No. 989—*Eucalyptus calycogona*, Turcz. var. *gracilis*, Maiden.

No. 1646—*Galium parisiense*, L. var. *australe*, Ewart.

No. 1024 A—*Acacia leptoneura*, Benth. var. *eremophila*, Ewart & White.

No. 1087—*Olearia homolepis*, F. v. M. var. *pilosa*, Ewart.

No. 1347—*Styphelia elegans*, D. C. var. *brevior*, Ewart & White

No. 1359—*Eremophila Woollsiana*, F. v. M. var. *dentata*, Ewart & White.

No. 1944—*Caladenia latifolia*, R. Br. var. *glandula*, Ewart & White.

No. 1322—*Conostylis aurea*, Lindl. var. *longiscapa*, Ewart.

No. 1056—*Hakea sulcata*, R. Br. var. *intermedia*, Ewart & White.

No. 2086—*Calothamnus homalophyllus*, F. v. M. var. *angustifolia*, Ewart.

No. 1144—*Triglochin mucronata*, R. Br. var. *longifolia*, Ewart.

By Authority: Fred. Wm. Simpson, Government Printer, Perth.

13. CONTRIBUTIONS TO THE FAUNA OF ROTTNEST ISLAND.

No. IV.

Western Australian Sepiidae.

By Bernard C. Cotton, Assistant Conchologist, South Australian Museum.

(With one Text Fig. 17, and Three Plates, XIV., XV., and XVI.)

Communicated by L. Glauert.

(*Read* 12*th March*, 1929. *Published* 25*th July*, 1929).

By courtesy of the Trustees of the Western Australian Museum, its Curator, Mr. L. Glauert, forwarded for examination a large number of cuttle bones collected in Western Australia. Ten species belonging to seven genera have been recognised; five of these species have already been described by various authors, and five others are here described as new.

Solitosepia, Iredale, Austr. Zoologist, iv., pt. 3, Feb. 22, 1926, p. 188.

S. glauerti n. sp. Pl. XIV., figs. 3 and 4.

Sepion oval length about twice the width. Spine dorsally oblique, keeled ventrally. Dorsum cream-coloured, pustulose; three narrow ribs radiate from the spine, the central most distinct. Venter slightly swollen orally, median sulcus very shallow, striae semicircular. Outer cone thin, calcareous. Inner cone well developed.

Type.—50mm. long, 23mm. wide, 6mm. thick. Rottnest Island.

A specimen from Cottesloe measures 32.5mm. x 15.5mm. x 3.6mm.

Diagnosis.—It approaches *S. mestus* Gray, but this is larger and comparatively wider, and its spine does not point dorsally. Named after Mr. Ludwig Glauert, the Curator of the Western Australian Museum.

S. hendryae n. sp. Pl. XV., figs. 1 and 2.

Sepion narrow, pointed orally, length more than three times the width (some individuals comparatively narrower). Spine slightly concave ventrally, and obsoletely keeled. Dorsum salmon-coloured, coarsely pustulose; three ribs radiate from the spine, lateral indistinct, central more prominent; chitinous edge obsolete at the oral eight. Venter swollen, median sulcus deep, extending to the oral tip; striae close set, produced to a median angle, which points orally. Outer cone thin, calcareous, extending in front of the spine. Inner cone prominent aborally, becoming indistinct orally.

Type.—77.5mm. long, 22.7mm. wide, 6.2mm. thick. Rottnest Island.

One specimen from Cottesloe measures 51mm. x 13.5mm. x 4.2mm., and another 76.5mm. x 24.2mm. x 7.3mm.

Diagnosis.—It differs from *S. plangon* Gray, the New South Wales species, in that (a) its outer cone extends in front of the spine in a calcareous, not corneous rim; (b) its oral end is more pointed; (c) its dorsum is

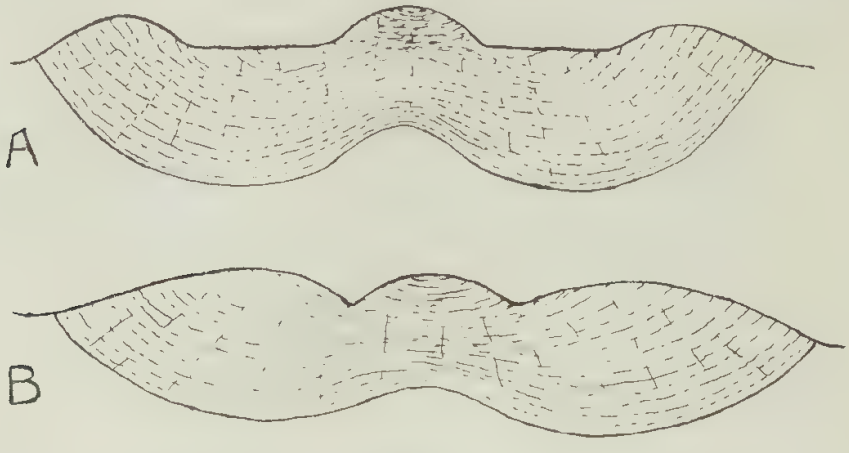


Fig. 17.

A *Solitosepia hendryae* n. sp.
B *Solitosepia plangon* (Gray).

more pustulose; (d) its transverse section shows on the dorsum a central rounded rib with a flat area on either side, and close to the margin a second rounded rib, less prominent than the central, as in A, fig. 17. In *S. plangon* the dorsum is as in B, fig. 17. This species is named after Miss M. E. Henry, the authoress of a paper entitled "A Correlation of Recent and Subrecent Marine Mollusca of the Swan River district."

S. occidua n. sp. Pl. XIV., figs. 1 and 2.

Sepion oval, length more than twice the width. Spine dorsally oblique, ventrally keeled. Dorsum rounded, finely pustulose; three indistinct subequal ribs radiate from the spine, the central cream-coloured, elsewhere (except the outer cone) pink. Chitinous margin passes narrowly in front of the spine. Venter slightly swollen, median sulcus reduced to a mere longitudinal groove; striae with a wide central loop and a much smaller one on either side. Outer cone thin, calcareous. Inner cone well defined.

Type.—48mm. long, 19mm. wide, 4.5mm. thick. Rottnest Island.

Specimens were also received from Cottesloe.

Mesembrisepia, Iredale, Austr. Zoologist, iv., pt. 3, Feb. 22, 1926, p. 190.
M. novaehollandiae (Hoyle).

1909. *Sepia novaehollandiae*, Hoyle, Pro. Roy. Physical Soc. Edn., xvii., p. 266.

Sepion elongately oval, length about three times the width. Spine strong, rounded, mounted on a callous base. Dorsum pink, gradually becoming cream-coloured laterally; three indistinct ribs radiate from the spine; finely pustulose, more coarsely in the area around the base of the spine. Venter swollen, thickest about one third the length from the oral end; median sulcus varying in depth; striae close-set and wavy. Outer cone fairly wide, calcareous. Inner cone well developed, longitudinally finely striate.

Type.—78mm. long, 30mm. wide. Kangaroo Is., S. Austr.

A large specimen from Cottesloe measured 150mm. x 45mm. x 15mm.

This appears to be the commonest and most variable species found in the Adelaidean region. Among hundreds of specimens from South and Wes. Australia the numerous variants are not separable into any distinct varieties.

M. chirotrema (Berry).

1918. *Sepia chirotrema*, Berry, "Endeavour" Biol. Res., iv., p. 268, pl. lxxiv., figs. 3-9, pls. lxxv.-lxxvii.

Sepion elongately oval, about three times as long as broad. Spine strong, straight, rounded, dorsally oblique, mounted on a valid callous base. Dorsum cream-coloured, with a pink tinge in fresh specimens; three distinct ribs radiate from the base of the spine, the central most prominent; coarsely pustulose, pustules arranged in concentric lines corresponding with the lines of growth, and becoming coarser towards the aboral end, and finally agglomerating to form sharp ridges around the basal area of the spine. Chitinous margin, thick, wide, well-defined. Venter with a deep median sulcus extending to the last loculus; striae wavy, close-set. Outer cone wide, thickly clacified, extending in front of the spine. Inner cone well developed, longitudinally finely striate.

Type.—South of Kangaroo Is., South Australia. Dimensions not given.

Habitat.—Cottesloe and Rottnest Is. Largest specimen examined measures 145mm. x 12.5mm. x 13mm.

Diagnosis. This is easily distinguishable from *M. noraehollandiae* (Hoyle) by the coarser sculpture of its dorsum, stronger spine, and deeper ventral sulcus. It is probably the deep water form of *M. noraehollandiae*, in which case it should be named *M.* (*noraehollandiae*) *chirotrema*, Hoyle.

Glyptosepia, Iredale, Austr. Zoologist, iv., pt. 3, Feb. 22, 1926, p. 191.

G. hedleyi (Berry). Pl. XVI., figs. 3 and 4.

1918. *Sepia hedleyi*, Berry, "Endeavour" Biol. Res., iv., p. 258, pl lxxi.-lxxii.

Sepion elongate-oval, oral end attenuate and somewhat contracted laterally. Spine long, straight, keeled.

Dorsum pinkish-cream coloured, with a narrow raised central rib, obsolete in some specimens; pustulose, pustules fusing at the aboral end to form ridges; occasional transverse undulations correspond with the lines of growth. Venter slightly swollen, no median sulcus; striae close-set; almost straight transversely, turning abruptly aborally at both sides. Outer cone narrow, thin; inner cone very narrow.

Type.—South of Kangaroo Is., South Australia. Dimensions not given

Habitat.—Cottesloe and Rottnest Is. Largest specimen measures 120mm x 41mm. x 11.5mm. The specimen illustrated measures 107mm. x 39mm x 9mm.

Decorisepia, Iredale, Austr. Zoologist, iv., pt. 3, Feb. 22, 1926, p. 193.

D. cottesloensis n. sp. Pl. XVI., figs. 1 and 2.

Sepion elongate-oval, pointed oraly, length more than twice the breadth Spine rounded, dorsally oblique. Dorsum cream-coloured (outer cone bluish-white), finely pustulose; slightly raised narrow central rib, and wider in distinct lateral elevations; chitinous margin thin. Venter slightly swollen, median sulcus shallow, striae semi-circular, extending over rather less than two thirds the length of the shell. Outer cone thin, slightly calcareous, crossing in front of the spine; inner cone very narrow.

Type. 42.6mm. long, 18.3mm. wide, 4.5mm. thick. Cottesloe.

Only one specimen of this species was received.

Diagnosis. It differs from *D. rec*, Iredale, in being wider, outer cone narrower aborally, dorsal surface cream-coloured and not deep rose.

Arctosepia, Iredale, Austr. Zoologist, iv., pt. 3, Feb. 22, 1926, p. 193.

A. braggi (Verco).

1907. *Sepia braggi*, Verco, Trans. Roy. Soc. S. Austr., xxi., p. 213, pl. xxvii., fg. 6.

Type.—60mm. long., 11mm. wide, 4.75mm. thick. Glenelg, South Australia.

A specimen from Cottesloe is 64.5mm. x 11mm. x 41.7mm. Common along the coast of South and South-West Australia.

Amplisepia, Iredale, Austr. Zoologist, iv., pt. 3, Feb. 22, 1926, p. 194.

A. apama (Gray).

1849. *Sepia apama*, Gray, Cat. Moll. Brit. Mus. (Cephalopoda), p. 103

1888. McCoy, Prod. Zool. Viet. Decade xix., pl. 188-190.

Type. Port Adelaide, S. Australia.

McCoy, gives an exhaustive description. This common species varies considerably in shape and the comparative depth of the outer cone. The spine is comparatively insignificant in juveniles, and absent from adults. An example from Cottesloe measures 155mm. in length.

Crumenasepia, Iredale, Austr. Zoologist, iv., pt. 4, April 30, 1926, p. 239.

C. ursulae n. sp. Pl. xv., figs. 3 and 4.

Sepion elongate-oval, length nearly three times the breadth. Spine round, dorsally oblique, mounted on a callous base. Dorsum cream-coloured coarsely pustulose, pustules agglomerating aborally to form vermicular ridges; three indistinct ribs radiate from the base of the spine; chitinous margin thick, well defined, crossing in front of the spine. Venter slightly swollen, with a wide shallow median sulcus; striae close-set; striated area about half as long again as the unstriated area. Outer cone calcareous; inner cone chitinous, forming a pocket at the aboral end.

Type.—180mm. long, 65mm. wide, 13mm. thick. Cottesloe; also Rottnest Is.

Every specimen examined is cracked about the aboral end, within the area enclosed by the corneous inner cone, probably due to the postmortem contraction of the latter.

Diagnosis.—It approaches *C. halliana*, Iredale, from Howick Is., N. Queensland, but (a) its inner cone is longer and wider, and has its sides more nearly parallel, and a more rounded aboral end, (b) the striated area is narrower and shorted.

This species is named after Miss Ursula Glauert, who collected the type specimen.

The following species have been recorded from Western Australia, but no examples of them have been received from that State.

Sepia indica (d'Orbigny).

1839. *Sepia indica* d'Orb., Ceph. Acet., p. 288, No. 21.

This Indian species was recorded from Western and North-Eastern Australia by Brazier. The corneous inner cone suggests its reference to the genus *Crumenasepia*, but its shape differs from that of *C. ursulae* described in this paper.

Sepia irvingi Meyer.

1909. *Sepia irvingi*, Meyer. Fauna Sudwest Austr. ii., p. 333, figs. 7-10

Type.—Cockburn Sound.

This is possibly a variant of *Mesembrisepia novaehollandiae* Hoyle.

Sepia latimanus Quoy & Gaimard.

1832. *Sepia latimanus*, Quoy & Gaimard, Zool. Voy. "Astrolabe," ii., p. 68, pl. ii., fig. 2.

1909. Meyer. Fauna Sudwest Austr., ii., p. 331.

Type.—New Guinea.

Meyer recorded this species from Shark Bay.

Sepia galei Meyer.

1909. *Sepia galei*, Meyer, Fauna Sudwest Austr., ii., p. 332, figs. 4, 5, 6,

The characters of this peculiarly shaped species render its reference to any described genus difficult.

Sepia rostrata d'Orbigny.

1826. *Sepia rostrata*, d'Orbigny, Ceph. Acet., p. 284, pl. 8, fig. 6.

1892. *Sepia rostrata*, Brazier Cat. Austr. Cephalopoda, p. 12.

d'Orbigny records it from Bombay and New Holland; Brazier from Western Australia. It is probably a species of *Acanthosepia*.

Plate XIV.

Figs. 1, 2.
Solitosepia occidua n. sp.

Figs. 3, 4.
Solitosepia glauerti n. sp.

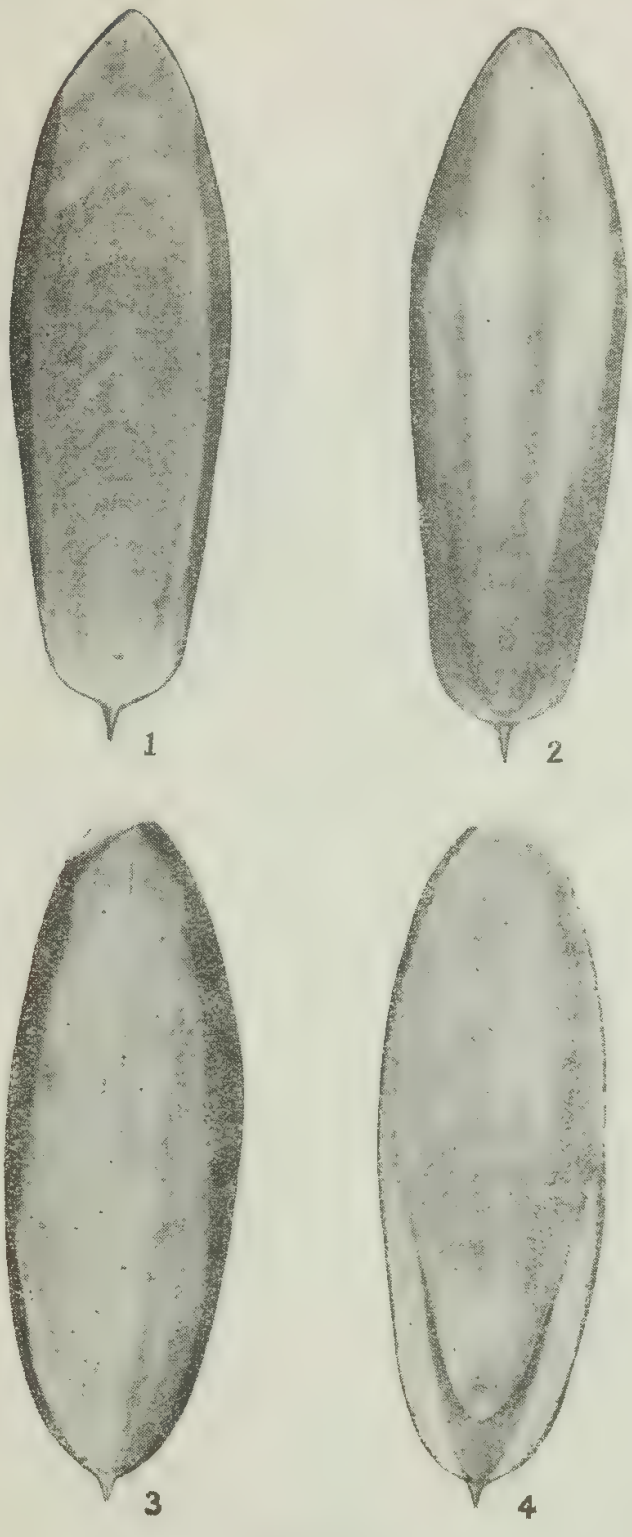


Plate XV.

Figs. 1, 2.
Solitosepia hendryae n. sp.

Figs. 3, 4.
Crumenasepia ursulae n. sp.

Plate XVI.

Figs. 1, 2.

Decorisepia cottesloensis n. sp.

Figs. 3, 4.

Glyptosepia hedleyi Berry.

By Authority: JOHN LEE, Acting Government Printer, Perth.

14.—CONTRIBUTIONS TO THE FAUNA OF ROTTNEST ISLAND.

No. V.

Opiliones in the Western Australian Museum.

By Professor C. Fr. Roewer, Bremen.

Translated from the German by L. Glauert.

(With One Text Figure 18).

(*Read* 12*th March*, 1929. *Published* 25*th July*, 1929.)

The very few Opilionids that have as yet been recorded from Western Australia, have all been immature specimens. Dr. J. C. C. Loman, who examined the collection obtained by Michaelsen and Hartmeyer in 1905, when dealing with that material, was able to identify but a single species by means of two not quite mature, and many young animals,* the balance of the specimens considered to represent Phalangiidæ, being too immature to allow a more definite opinion to be expressed.

The collection of Western Australian Opilionids kindly sent to me for examination by Mr. L. Glauert, the Curator of the Western Australian Museum, is more comprehensive than any series previously examined, but, unfortunately, is also mainly composed of young or immature animals. They are mostly Triaenonychidæ (Triaenonychinæ), but include also a few quite immature Palpatores (Phalangiinæ) and three examples of a species belonging to a new genus of the Phalangodidæ (Samoinæ) which are of particular interest because they constitute the first record of the presence of Phalangodids on the Australian continent. Further they belong to the sub family Samoinae, which, up to the present, is represented by a few forms collected in Samoa, Fiji and the Seychelles.

Family TRIAENONYCHIDAE, Soerensen 1886.

1903 Pocock described under the name *Triaenonyx aspera*, a Triaenonychid represented in the British Museum by a single specimen—the type—which had reached that Institution from "Australia." In his description Pocock gives the length of the first, third and fourth legs, but omits that of the second, although he notes that the tarsus of this leg is 13 jointed. In view of the fact that the only specimen in London, the type, had lost its second pair of legs it must have been impossible to determine either the length of the limb or the number of segments in its tarsal joint.

Neither Pocock (1903) nor Loman (1910) have noted the number of articles in the terminal joint of the tarsus, although Soerensen had already in 1902 directed attention to the great importance of this feature. The specimens of *Nuncia* before me in 1914 and 1923, had three joints in the tarsus of the second leg, and the series did not include *Nuncia aspera*,† so that I was unable to give the number of articles in the terminal segment of its second leg. The specimens from Western Australia now before me, which agree in every character with Pocock's description of *Nuncia* (*Triaenonyx*) *aspera*, all possess when adult four articles in the terminal segment of the tarsus of the second leg.

* Fauna Sudwest Australiens, vol. III., part 4. Opiliones by Dr. J. C. C. Loman, Jena, 1910, p. 127 *et seq.*

† In 1914 I wrongly quoted the specific name as *asperus*, an error which also appeared in "Weberknechte der Erde" of 1923.

Further, *Nuncia* (*Triaenonyx*) *aspera* is the only species of the genus occurring in Western Australia,* the others, with the exception of *N. seriata*, Roewer, from New South Wales, having been obtained in New Zealand. It is therefore necessary to separate Pocock's *aspera* from these forms with three articles in the terminal segment of the tarsus of the second leg, and I propose for them the name *Nunciella*.

The diagnosis of this new genus would read as follows:—

Nunciella, nov. gen.

1903 *Triaenonyx* (part.), Pocock in Proc. Zool. Soc. London 1902, Part II, p. 404.

1910 *Triaenonyx*, Loman in Die Fauna Sudwest Australiens Band III., Lief 4. Opiliones p. 133.

1914 *Nuncia* (part.), Roewer in Arch. Naturg. Vol. 80, A. fasc. 12, p. 80.

1923 *Nuncia* (part.), Roewer Die Weberknechte der Erde, p. 592.

Characters of the Family Triaenonychidae (Roewer Weberknechte der Erde, p. 585).

Characters of the Sub-family Triaenonychinae (Roewer op. cit. p. 586) with the following additions: Carapace shorter than the scutum: frontal margin of the carapace without transverse furrow. Eye tubercle broader than high, rising in front directly from the frontal margin, unarmed. Legs: first leg unarmed: metatarsus of the 1st-4th legs with the calcaneus much shorter than the astragalus: middle member of the tridentate claw of the third and fourth tarsi much stronger than the outer members. Terminal joint of the first tarsus biarticulate, that of the second quadriarticulate; tarsus of the first leg triarticulate, that of the second leg with more than six joints (8-14 joints). The third and four legs have the tarsus always four-jointed.

Western Australia 1 species.

Nunciella Aspera (Pocock).

Synonymy as for the genus.

Diagnosis as for the genus with the following special features:—The basal segment of the three-jointed tarsus of the first leg much expanded in the male, not expanded, normal, in the female.

Localities:—

Australia, without further particulars—1 specimen, identified by Pocock in 1903 as *Triaenonyx aspera*. Type British Museum. The basal segment of the tarsus of the first leg not expanded.

South Western Australia:—

Pinjarra, one specimen not quite mature.
Lunenburg, two pulli.
Brunswick, one specimen, almost mature.
Bridgetown, one pullus.

All identified by Loman 1910 as *T. aspera*. Mus. Hamburg.

The Present Collection of the Western Australian Museum, Perth:—

Darlington, one male, one female. 28-526 Col. L. Glauert, May, 1928.
Cape Leeuwin, one female 1914-993 col. W. B. Alexander, July, 1914.
Serpentine, one male, four pulli 27-778-792 col. L. Glauert, June, 1927.
Serpentine Falls, one male one female, four pulli 28-746-753 col. L. Glauert, August, 1928.

* See Loman 1910.

Near Lake Herschell, Rottnest Island, one pullus, 27-1099 coll. L. Glauert, August, 1927.

Near Lake Herschell, Rottnest Island, thirteen pulli, 27-1100/12 coll. L. Glauert, September, 1927.

Point Clune, Rottnest Island, six pulli, 27-1113 1118 coll. L. Glauert September, 1927.

North Point, Rottnest Island, three pulli, 27-1119 1121 col. L. Glauert, September, 1927.

Family PHALANGODIDAE, Simon 1879.

The following new genus and species of the Sub-family Samoinae is present in the collection.

Bindoona, nov. gen.

Eye tubercle close to the frontal margin of the carapace, low, rounded above, unarmed, boundary between the carapace and areae of the scutum indefinite, scutum and free tergites of the abdomen unarmed, stigmata distinctly visible. Coxae of all the legs unarmed. Chelicerae normal in structure. Pedipalpi with all the joints spinose, femur equal to the other joints in thickness with a medial-apical spine; legs unarmed; number of joints in the tarsi of the legs 1 to 4, 2-3-5-5; terminal segment of the tarsus of the first leg undivided, that of the tarsus of the second leg two-jointed; tarsi of the third and fourth legs with a pair of simple, not serrated, claws, without pseudonychium, but with dense scopula.

Western Australia one species.

Bindoona glauerti, nov. sp. (fig. 18.)

Length of the body 1.3 mm.

Surface of carapace and scutum finely and closely granular, otherwise unarmed, furrows absent. Eye tubercle close to the frontal margin of the carapace, transversely oval, low, unarmed, not basally con-

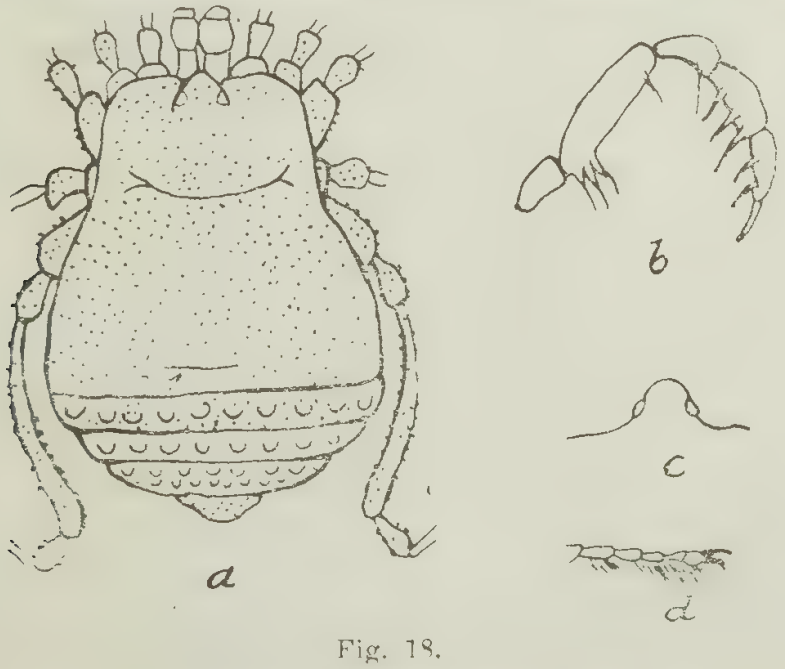


Fig. 18.

a. ***Bindoona glauerti*** nov. gen., nov. sp.
b Inner view of palp.
c Frontal view of eye tubercle.
d Tarsus of fourth leg with scopula.

stricted, the two eyes quite unpigmented. Free tergites of the abdomen: first and second free tergites with one transverse row of coarse, blunt tubercles, third free tergite with two transverse rows of same, tergites otherwise unarmed. Operculum anale only finely granular. Free sternites of the abdomen and surface of the coxae of all the legs finely granular. Stigmata distinctly visible in the furrow between stigmate-sternite and the fourth Coxa; Cheliceae smooth, their first joint with a dorsal apical swelling. Pedipalpi: Trochanter unarmed, femur with three ventral-basal and one medial-apical spines, patella ventrally with one apical spine on either side, tibia with three ventral-medial and two ventral lateral spines. Tarsus ventrally with two spines on either side. Legs unarmed, femora slender, slightly sigmoidal, number of joints in the Tarsi 2, 3, 5, 5. Colour of the body and of all the appendages pale rusty yellow. Western Australia, South Bindoon, 3 specimens 27.672.674. Coll. L. Glauert, May, 1927

Type in W.A. Museum, Co-type in Coll. Roewer.

Family PHALANGIIDAE.

The following specimens of Palpatores belonging to the family Phalangiidae were too immature to be indentified: -

Peppermint Grove, near Perth, 1 pullus 27-1388. Coll. L. Glauert, September, 1927.

Pemberton, 1 pullus 28-75. Coll. R. C. Whiteford, January, 1928.

Serpentine Falls, 1 pullus 28-747. Coll. L. Glauert, August, 1928.

Serpentine Falls, 1 pullus 28-747. Coll. L. Glauert, August, 1928.

By Authority, John Lee, Acting Government Printer, Perth.

15.—CONTRIBUTIONS TO THE MINERALOGY OF WESTERN AUSTRALIA.

Series IV.

By

EDWARD S. SIMPSON, D.Sc., B.E., F.A.C.I.

(With Four Text Figures 19, 20, 21, 22).

(*Read* 14*th May*, 1929; *Published* 25th *July*, 1929.)

CONTENTS.

(1) APATITE, MT. FRANCISCO, N.W. DIV.

A grey apatite has been found in large coarsely crystalline masses at Mt. Francisco. The colour ranges between Ridgways "slate-grey" and "deep neutral grey." Small imperfect crystals are only occasionally seen penetrating the massive mineral from one of its boundaries. They are a combination of *m* (10—10) and *x* (10—11) with sometimes *s* (11—21) and *c* (0001). Occasional small nests of biotite are enclosed in the masses, and minute scales are visible on fracture faces. Although great care was taken in selecting material for analysis, a little biotite was unavoidably included. The analysis, made by Mr. D. G. Murray, showed:

—	SiO_2	Al_2O_3	FeO	MnO	CaO	MgO	P_2O_5	F	Cl
Per cent. ...	·64	·45	·36	·19	53·74	·58	41·92	2·74	·06
Mols.	11	4	5	2½	958½	14	295	144	2

—	CO_2	H_2O+	H_2O-	Total	$O=F_2$	Net total	Sp. gr.
Per cent.	·06	·46	·04	101·24	1·16	100·08	3·196
Mols.	1	51 (OH)	—	...	...	...	...

The established formula for fluorapatite is $CaF_2.3Ca_3P_2O_8$, or in simpler terms, $Ca_5F(PO_4)_3$. In comparing the results of the above analysis with this it is to be remembered that (OH) is found to displace F in part in a very large number of minerals, and apparently does so in apatite. The calculated ratios from the analysis are:

Ca	F + (OH)	P
4·982	1·015	3·000

with F to (OH) approximately 3 to 1.

It is highly probable that all the recorded cases of "Oxidapatite" (Voelkerite),* in which CaO is supposed to replace part of the CaF_2, are really cases of the substitution of $Ca(OH)_2$ for CaF_2, as in this instance, since it is a common error in analysis to get low figures for both fluorine and hydrogen.

(2) CAESIUM—BERYL, WODGINA, N.W. DIV.

When visiting Wodgina in 1927 the Author found on a dump near the north end of the main tantalite vein (albite pegmatite) several large masses of a white mineral closely resembling quartz, and in fact locally considered to be so. The presence in one specimen of a very faintly discernible cleavage made one hesitate as to its identity, and physical and chemical tests in the laboratory proved that it was beryl.

The mineral occurs in a large pegmatite vein in Archæan greenstone. It is in shapeless masses apparently up to 10 kilos at least in weight, and is not only devoid of external form, but also lacks, except in rare instances, any trace of the usually typical basal cleavage. Its colour in mass is milk-white to water-white, and it is translucent in thicknesses of 0·5 to 1·0 cm. or more. On fracture faces occasional minute flakes of a silvery mica are observable. The chemical composition and physical properties are given below.

A few hundred yards further south on the same vein a single mass of beryl of very different appearance was found embedded in the massive albite. This mineral was streaky grey in colour (light to dark carbon gray) with patches of greenish grey, obviously due to microscopic inclusions, possibly of a chlorite or hornblende. Like the other beryl, it was devoid of crystal faces or cleavage. The results of the physical and chemical examinations are below :

	SiO_2	BeO	FeO	MnO	MgO.	CaO	Li_2O	Na_2O
White beryl	66·42	11·20	*nil*	*nil*	*nil*	·30	·82	1·01
Grey beryl	60·58	12·00	tr.	0·7	1·18	3·98	·97	1·12

	K_2O	Cs_2O	H_2O +	CO_2	Al_2O_3	Fe_2O_3	Total.
White beryl ...	tr.	·72	2·20	*nil*	17·97	*nil*	100·64
Grey beryl	tr.	·92	3·00	·02	14·55	1·39	99·78

	Sp. gr.	O	E
White beryl ...	2·72	1·581	1·575
Grey beryl	2·79	1·588	1·582

* *Vide* Winchell, Elements of Optical Mineralogy, II., 129 ; Doelter Handb. der Mineralchemie, III. (1), 335.

Both minerals therefore prove to consist of the rare caesium-bearing variety of beryl, sometimes known as rosterite or vorobyevite. The presence of caesium was suggested by the typically pale colour of the chloroplatinate precipitate, and amply confirmed by the spectroscope, which revealed only traces of potassium, but strong evidence of caesium.

Caesium beryl is usually found in lithia-bearing pegmatites and the Wodgina occurrence is no exception to the rule, as the pegmatite which carries the beryl encloses large masses of lepidolite and lithiophilite.

(3) CINNABAR, MARBLE BAR, N.W. DIV.

Whilst preparing a history of mineral discoveries in the State it was found that although some small specimens of cinnabar have been in the possession of the Author for about 15 years, no permanent record has been made of the discovery of this mineral.

The specimens come from the old Just in Time diggings, four miles due South of Marble Bar, and consist of three pieces of the pure mineral weighing respectively 0.4, 0.3 and 0.1 gramme. They are well water-worn and were said to have been obtained when prospecting for alluvial gold. They are between "rosolane purple" and "Schoenfelds purple" (Ridgway) in colour, have a specific gravity of 8·14, and yield mercury when heated with lime in a closed tube.

The geoogical structure of the country at the Just in Time diggings has been described by A. Gibb Maitland.* On the north-east side are the massive and schistose greenstones of the Warrawoona Series (Archaean). On the south-west side these are overlain by the slightly dipping conglomerates, shales, sandstones and lavas of the Nullagine Series (Archaean?). The Warrawoona Series is known to include in many places ultrabasic rocks which are often favourable to the occurrence of mercury.

(4) GLAUCOPHANE, SIDERITE AND CORUNDUM, GREENBUSHES, S.W. DIV.

In 1928 the Government began a series of bores on the Greenbushes tinfield to test the tin-bearing "lodes" (albite pegmatites) below the deepest mine workings, which then only extended to about 150 feet in depth, and included very little driving. A bore on the Dixie M.L. 632 passed through nine different albite pegmatite veins, none of which carried more than traces of tin where they were intersected. Two of these veins were unusual in that they contained appreciable amounts of a bluish-grey mineral which proved to be glaucophane, a mineral previously unknown in Western Australia except for a doubtful occurrence in epidotised dolerite on Synnott Creek, Kim. Div.

Almost throughout the No. 7 vein, extending from 242 to 266 feet below the surface, a deep bluish-grey concentrate was obtained by vanning, followed by concentration with methylene iodide with a density of 2·70. Under

* G.S.W.A., Bull. 40, p. 249-255.

the microscope the bluish mineral was in small, mostly flat, prisms reaching a maximum size of about 0.5 x 0.2 x 0.1 mm. As far as could be determined it appeared that the principal forms present were *m* (110) and *a* (100), with possibly *b* (010). No terminal planes were seen, but a vertical striation was often observable. Crystals lying on *a* or *m* gave biaxial figures with straight extinction. Rarely thin prisms, apparently lying on *b*, gave an extinction angle ranging from 4° to 6°. The specific gravity (by CH_2I_2) was 3·15 ± ·03. Optical tests showed that Z and X lay in the plane (010), with Z making an angle of 4° to 6° with the vertical axis. Pleochroism was very marked, with maximum absorption approximately parallel to the elongation, the common scheme being: Z deep cobalt blue; Y purplish blue; X colourless to very light amber. Ng was found to be 1·640; Nm 1·637; Np 1·624; all ± ·003. A few pleochroic haloes were observed round minute inclusions, and an occasional small zircon was recognisable embedded in a crystal. The macroscopic appearance of the mineral in this vein is unknown, as it was first recognised in the concentrates from the crushed rock. The characters determined on the powder leave no doubt, however, as to its identity.

After the detection of glaucophane in the No. 7 vein a close examination was made of the remaining cores before crushing. In certain portions of No. 8 vein extending from 273 to 291 feet in the bore glaucophane was again encountered. For a few inches near the upper margin of the vein, radial aggregates of minute lavender-blue prisms were quite common, the masses reaching a maximum of one centimetre in diameter. They were embedded in a mixture of granular albite, quartz and biotite, with small amounts of garnet and other minerals. A crushed concentrate of the lavender mineral presented all the significant characteristics of that from the No. 7 vein, but the crystals were more acicular, and some showed a parting at right angles to the elongation on one face (*a*?) but making an angle of 64° to 66° with the elongation on another (*b*).

The minerals accompanying glaucophane in the No. 7 vein were of more than passing interest. Throughout the 24 ft. of core granular albite and quartz were the most abundant minerals. Amongst the minor minerals schorl, ilmenite, garnet and apatite were the most common, with traces of cassiterite, zircon, sphene, biotite, pyrite and rutile. Glaucophane was detected in the upper 14 ft. of core, and was most abundant in the first 6 feet. The concentrate from the first four feet carried about 70 per cent. of siderite in dull yellow to brown granular masses. This is the first time the Author has seen or heard of this mineral in a pegmatite. Apatite was common throughout, occurring in stout prisms about 0·2 mm. in length, presenting characteristic optical properties and readily soluble in cold dilute nitric acid. Finally the concentrate from the middle three feet of the vein included some small corundum crystals. Similar crystals were more plentiful in a similar vein at 215 ft. in the No. 4 bore on the adjacent Cornwall M.L. There they formed imperfectly developed prisms and bipyramids about 0·2 x 0·06 mm. in size. The presence of small rhombohedral truncations, the corroded surface, straight extinction, high refringence, low birefringence with negative elongation, and the slight pleochroism (O, lilac; E, colourless) serve to identify the species.

(4) ILMENITE. WOODSTOCK, N.W. DIV., AND WANNAMAL, S.W. DIV.

MANGANILMENITE, Woodstock. A few miles south-east of Cunmagnunna Trig. (B4) on Woodstock Station (Lat. 21° 48′ S., Long. 115° 55′ E.) and not far from the place where the tanteuxenite previously described was found,* a number of angular pebbles were picked up on the surface, which proved to be composed of a very unusual variety of ilmenite. The country for some distance round consists of Archaean granite traversed by pegmatite veins, one of which was probably the original matrix of the mineral.

The pebbles varied from one to several centimetres in diameter and showed no signs of crystallisation beyond a single imperfect cleavage in most fragments and a small development of *c* (0001) and *s* (02-21) on one. They were brownish black within, but much weathered on the surface, which had a coating of light brown decomposition products.

One of the freshest looking fragments was freed from the latter as far as possible by chipping, immersed for a few moments in HCl and HF, and then well washed and dried. The analytical results obtained were:

	Fe_2O_3	FeO	MnO	M_2O	CaO	TiO_2	SiO_2	H_2O	Total
Per cent.	12·12	24·27	14·40	trace	Nil	51·79	·80	trace	100·38
Mols. ...	76	296	203	...	...	647	13	...	...

The specific gravity was 4·63.

If the whole of the Fe_2O_3 be considered as due to oxidation of primary FeO, the original ratio of FeO + MnO : TiO_2 becomes 651 : 647, practically one to one, corresponding to the generally accepted formula for ilmenite. The mineral from Woodstock, however, differs from normal ilmenite in the large proportion of the pyrophanite molecule ($MnTiO_3$) which is present. The only other analysis similar to it in this respect is one of a mineral from Rocroi, France, quoted by Doelter,† which shows 15.15 per cent. of MnO. Of this Doelter says: "it deserves to be provided with a distinct name."

For this manganiferous variety of ilmenite the name "manganilmenite" is suggested.

MENACCANITE, Wannamal. The molecules $FeTiO_3$ and Fe_2O_3 are completely isomorphous, and most ilmenites contain appreciable amounts of Fe_2O_3 even when quite fresh. A large number of unnecessary names have

* J.R.S.W.A. xiv. 46.

† HB. der Min. Chem. III. (1) 48.

been given to varieties of ilmenite differing only in the various proportions of the haematite molecule, but the old-established name menaccanite might well be retained for those with approximately equal molecules of $FeTiO_3$ and Fe_2O_3, say with 40 to 60 per cent. by weight of Fe_2O_3.

The only comparatively large deposit of ilmenite in the State belongs to this variety. It occurs in a low range of hills just east of the railway, between Wannamal and Mogumber, in Lat. 31° 10′, Long. 116° 5′. This range is composed of gneissic granite traversed by occasional dykes of greenstone. The actual outcrop of the menaccanite, except in one spot on Loc. 1589, is obscured by soil, but surface boulders were traced in a northerly line for about a mile, and, according to a local resident, continue for a further half-mile in each direction. Accompanying the loose surface boulders of menaccanite are boulders of epidiorite at frequent intervals, and the indications are that the titanium mineral is not in a continuous lode but exists as a series of large segregations in the epidiorite. On Loc. 1589 there is an outcrop of solid granular menaccanite standing as much as three feet out of the soil and covering an area of 10 to 15 square yards. An average sample from this, which included visible specks of kaolinised felspar, had the following composition:—

	Fe_2O_3	FeO	MnO,MgO	CaO	TiO_2	SiO_2	Al_2O_3	H_2O	Total
Per cent.	49·93	19·76	traces	*nil*	22·79	1·35	5·28	·60	99·71
Mols. ...	313	275	...	...	284	22	52	33	...

Previous samples collected along the same line of outcrops had yielded 21·60 and 26·30 per cent. of TiO_2. The character throughout is similar, rather finely granular black masses with minute inclusions of kaolinised felspar.

(6) MANGANOCOLUMBITE, TABBA AND MT. FRANCISCO, N.W. DIV., AND GIBRALTAR, CEN. DIV.

TABBA. The occurrence of manganocolumbite in association with manganotantalite at Tabba was referred to in the Annual Report of the Chemical Branch for 1927 (p. 17). Selected pebbles from detrital concentrates are mostly somewhat tabular, often showing the faces (100), (010) and (001) with occasionally (133). See Fig. 19. They are pure black to dark brown on the weathered surface, pure black on a fresh fracture, which is uneven, with a submetallic lustre. The specific gravity ranges from

6.15 to 6.28 in one parcel, and from 6.06 to 6.50 in another. Two pebbles from M.L. 317 with gravity varying from 6·22 to 6·25, and weighing in all somewhat less than six grammes, were analysed with the following results:

—	Ta_2O_5	Nb_2O_5	TiO_2	SnO_2	FeO	MnO	CaO	MgO
Per cent.	48·00	32·74	·91	·42	6·21	9·96	·08	·08
Mols. ...	108	123	11	3	86½	140½	1½	2

—	Fe_2O_3	Al_2O_3	H_2O	Total	Sp. gr.
Per cent.	·11	·23	·72	99·46	6·24
Mols.	...	2	10	...	...

The ratio of M_2O_5 : MO in this analysis is 462 : 461, the figures being due to Mr. H. P. Rowledge.

The fine powder of the mineral is almost pure black in colour, and under the microscope is completely opaque. These details are recorded, as some other manganese tantalo-niobates now under examination are much paler in colour, and are transparent under the microscope.

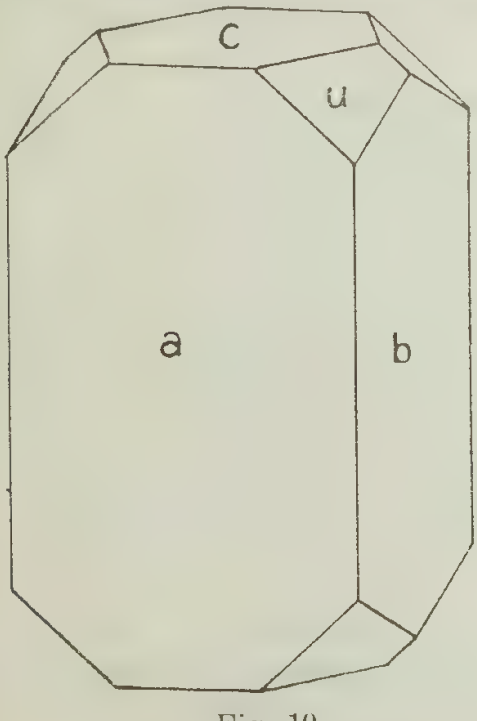


Fig. 19.
Manganocolumbite,
Tabba.

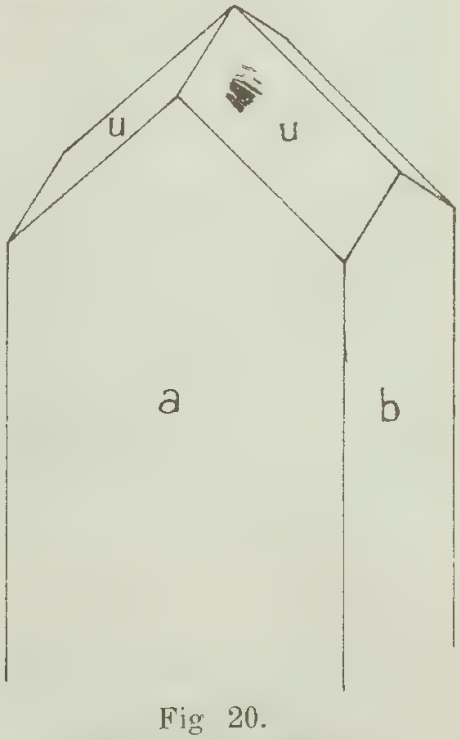


Fig 20.
Manganocolumbite,
Mt. Francisco.

MT. FRANCISCO. The existence of manganocolumbite in considerable quantities at this place has been known for many years, but attention has been again drawn to it by the recent sale of two tons of detrital ore from Hooley's lease.

The first find of the mineral was on the Congo Lease in pegmatite in the greenstone hills. Here masses up to a kilo in weight are to be seen embedded in albite and quartz. Good single-ended crystals have been collected, growing in parallel position from the sides of a narrow fissure filled by the crystals and secondary albite. The forms present in each case are (100), (010) and (133). See Fig. 20. On a fresh fracture the mineral is greyish black, the lustre being submetallic, and fracture uneven. The fine powder is brownish black, and under the microscope quite opaque.

A typical specimen had the following composition:—

	Ta_2O_5	Nb_2O_5	TiO_2	SnO_2	SiO_2	FeO	MnO
Per cent.	31·07	47·90	1·62	·40	·28	2·66	14·88
Mols.	70	180	20	3	5	37	210

	CaO	MgO	Fe_2O_3	Al_2O_3	H_2O	Total	Sp. gr.
Per cent.	·34	·16	trace	·35	·42	100·08	5·87
Mols.	6	4	...	3	23	...	...

The ratio of M_2O_5 : MO from these figures is 250 : 257. For the analysis I am indebted to Mr. W. W. Saw.

Other specimens from the same lease have specific gravities of 5·73 and 5·75, indicating a slightly higher ratio of Ta_2O_5 to Nb_2O_5.

The columbite lode on Hooley's lease is in granite four miles east of the greenstone hills. The vein is composed principally of albite and quartz with subordinate microcline lepidolite, muscovite and beryl. Loose pebbles of manganocolumbite were abundant near the outcrop when visited by the writer, and subsequently two tons were collected and shipped to America. Very few crystals were seen, the form being similar to those on the Congo Lease. Most of the pebbles were about 3cm. in diameter. Their specific gravity ranged from 5·16 to 6·32, indicating a range in composition from Ta_2O_5 12 per cent. with Nb_2O_5 68, to Ta_2O_5 45 with Nb_2O_5 37. In a bulk parcel the molecular ratio of MnO to FeO was 2·4 to 1·0; and of Nb_2O_5 to Ta_2O_5, 1·25 to 1·0.

GIBRALTAR. On this gold-mining field manganocolumbite has been found in two places about a mile apart, in each case the mineral occurring in angular fragments on the surface near the outcrop of siliceous pegmatites traversing Archaean greenstones.

On the Lloyd George gold-mining lease only a few small broken crystals have been collected, the faces *a* (100), *b* (010), *c* (001), *m* (110), *e* (021) and *u* (133) being represented. The specific gravity varies from 5·48 to 6·00, indicating a percentage of Ta_2O_5 varying from about 13 to 33, and the predominating base is manganese. This mineral has an uneven fracture, rather dull and black in colour. The powder is quite opaque.

On the Bendigo lease the mineral is much more plentiful. It resembles that described above in lustre, fracture and diaphaneity. An analysis of a typical specimen gave the following results:—

—	Ta_2O_5	Nb_2O_5	TiO_2	SnO_2	SiO_2	FeO	MnO
Per cent.	27·28	51·17	1·75	·12	·39	7·87	10·16
Mols.	62	192	22	1	6	110	143

—	CaO	MgO	Fe_2O_3	H_2O	Total	Sp. gr.
Per cent.	*nil*	*nil*	1·70	·14	100·58	5·81
Mols.	...	...	11	8	...	...

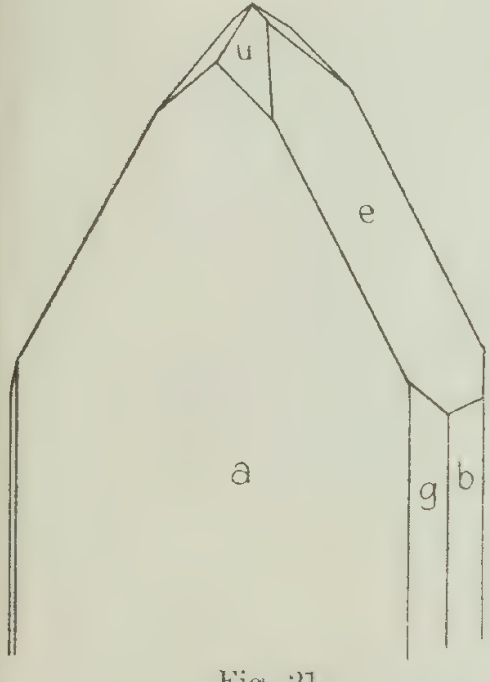


Fig. 21.

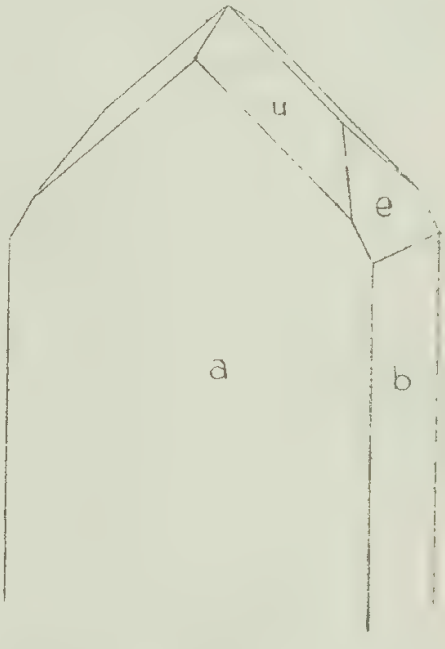


Fig. 22.

Manganocolumbite, Gibraltar.

Two other parcels of detrital pebbles of a similar type yielded the following approximate figures:—

—	Ta_2O_5	Nb_2O_5	TiO_2, etc.	FeO	MnO	Sp. gr.
A	16·2	62·9	1·4	9·7	9·8	5·57
B	20·8	57·0	3·5	9·3	9·4	5·68

The specific gravities determined on a number of specimens from the Bendigo lease ranged from 5·54 to 6·49, indicating a percentage of Ta_2O_5 varying from about 14 to 52. The crystalline forms observed were *a* (100), *b* (010), *c* (001), *m* (110), *y* (210), *g* (130), *e* (021), *u* (133). Two typical crystals are shown in Figs. 21 and 22.

(7) MICROLITE, WODGINA AND GREEN'S WELL, N.W. DIV.

Previous references have been made to the existence of microlite in the Wodgina district,* probably at Greens Well. Specimens received through reliable persons during 1928 leave no doubt but that microlite occurs in small quantities both at Wodgina itself and in the McPhees Range near Greens Well, 23 miles E.N.E. of Wodgina.

WODGINA. The mineral has only been detected so far in alluvial pebbles in a stream bed less than a mile north of the Tantalite Mine (M.L. 86). The surface of most of the pebbles is remarkably like that of meteoric stones, there being a thin coating of brownish black lateritic iron ore, and the form being "thumb marked" with rounded depressions. On a fresh fracture the pebbles below the thin crust are opaque and light to dark grey, sometimes greyish pink in colour. Examination of the fine powder under the microscope discloses that the major portion, which is microlite, is colourless to pale yellow in colour, transparent and isotropic. With it, and accounting for the grey colour in mass, are numerous minute granules of a black opaque mineral, probably tantalite. Individual pebbles vary in weight from about one gramme up to 40 grammes. Their specific gravity ranges from 5.54 up to 6.90, the latter apparently heavily contaminated with iron and manganese compounds. The mean of 29 determinations was 6.02.

For an analysis a pebble was chosen weighing 10 grammes and having only a thin coating of iron with a pale pinkish grey centre (between Ridgway 9'd and 9'd). The ferruginous coating was ground off with carborundum, the core then having a specific gravity of 5·77. The fine powder was practically the same colour as the mass. Under the microscope granules under 0·03 mm. were translucent, very pale yellow in colour, and isotropic. A small percentage of black opaque granules were present. The analysis showed:

Ta_2O_5	Nb_2O_5	TiO_2	SnO_2	SiO_2	CaO	MgO	MnO	FeO	Fe_2O_3
77·00	3·64	·51	·37	·40	12·78	*nil*	·11	·47	·72

Al_2O_3	Na_2O	K_2O	F	H_2O −	Total	Less O = F_2	Net total.
·55	1·18	·15	1·09	2·00	100·97	·46	100·51

There was no trace of Ce_2O_3, Y_2O_3, Sb_2O_5 or UO_2 to be detected in it.

The molecular ratios calculated from the above figures are:

$(Ta, Nb)_2O_5$	$(Ti,Sn)O_2$	(Ca,Fe)O	(Na,K)	F	H_2O
188	8	236	41	57	111

If the formula for microlite be $CaTa_2O_6.NaF$, these figures indicate a weathering of the mineral, the most marked effect being a removal of two-thirds of the sodium and fluorine, a slight concentration of the lime, and an assumption of water.

GREENS WELL. A few alluvial pebbles containing microlite have been obtained in McPhees Range near Greens Well. They resemble the Strelley specimens previously described.* With them is a crystal of pure tapiolite weighing 18 grammes and showing the forms (100), (001), (110), (111), the crystal being elongated parallel to the edge p^1 p^2, and having a specific gravity of 7·52.

Two large, but very imperfect crystals, resembled the Strelley specimens in having portions of the surface converted into opaque, greyish-yellow microlite. In consequence the bulk specific gravity is reduced to 6·95 and 6·85.

Several uncrystallised pebbles show much greater replacement of tapiolite by microlite: in one case, which is almost complete, the specific gravity is 6·01. In others it is 6·61, 6·64, etc., the approximate gravity of pure microlite being 5·70. One specimen exhibits on fracture a core of black tapiolite with a complete coating of light grey microlite 2 to 4 mm. thick. A partial analysis was made of the mixed parcel which was submitted to determine its value as a commercial tantalum ore. The result was:

Ta_2O_5	Nb_2O_5	SnO_2	CaO
75·76	6·92	·14	5·50

The fine powder of the whole ore under the microscope appears as a mixture of about 70 per cent. black opaque tapiolite and 30 per cent. colourless, transparent, isotropic microlite. Several of the larger particles of tapiolite are seen to be traversed by small veins of microlite.

(8) PSEUDOMORPH AFTER SPODUMENE, UBINI, CEN. DIV.

The amblygonite-bearing pegmatite vein in Archæan greenstones at Ubini was examined last year for other uncommon minerals. The chief constituents of the vein appear to be quartz, albite and microcline, with bunches of lepidolite, muscovite, and amblygonite in places, and rare specimens of cassiterite and manganotantalite.

A near-by vein which has been opened up for pottery felspar consists mainly of albite and microcline, with some lepidolite. From this vein a few specimens were collected, which appear to be felspathic replacements of spodumene (a mineral not yet detected at Ubini) similar to the "cymatolite" of Massachusetts and Connecticut.† The material is in dull white, slightly porous masses, with a subfibrous structure at right angles to the broadest face. The masses reach 12 x 10 x 8 cm. in size and are closely associated with perfectly unweathered and coarsely crystallised albite and lepidolite.

* Jour. R.S.W.A., xiv., 48-49.

† Dana, Sys. of Min. VII., 368.

An analysis was made of a characteristic fragment which had an apparent specific gravity in CH_2I_2 of 2·59:

SiO_2	Al_2O_3	Fe_2O_3	MgO	CaO	K_2O	Na_2O	Li_2O	H_2O —	H_2O—	Total
69·64	18·28	trace	·28	*nil*	4·87	6·36	trace	·63	·33	100·39

This corresponds approximately to an intimate mixture of:

Albite.	Microcline.	Muscovite.	Quartz.	Talc.?
53·8	21·7	10·1	13·5	·09

(9) SPINEL, GIBRALTAR, CEN. DIV., AND PEMBERTON, S.W. DIV.

Spinel has not, up to the present, proved to be a common mineral in Western Australia, though its natural matrices, olivine and serpentine rocks, are widespread. The only records of its occurrence are as large segregations in basic rocks at Mt. Francisco * and Miling,† and as occasional grains in heavy black sands at several points in the far South-West.

GIBRALTAR. An unusually black and fine-grained rock collected in an open cut on the Lloyd George Mine was found on sectioning to be a very fresh peridotite. The chief constituent was granular olivine, much cracked, but with only very thin films of serpentine along the cracks. Minor constituents were a white mica, magnetite and pyrite. The most striking constituent of the rock, however, was a transparent green (Ridgway 31″ k) spinel, which was very abundant in dense groups and strings of granules, 0·02 to 0·20 mm. in diameter.

PEMBERTON. As an example of the South-West occurrences may be taken that at Pemberton. Three sands collected from creeks between Pemberton and Fly Brook, and partly concentrated, were composed of the following minerals in descending order of frequency:—

A. Quartz, garnet, rutile, ilmenite, kyanite, spinel, zircon.

B. Quartz, felspar, ilmenite, zircon, rutile, kyanite, spinel, staurolite, garnet.

C. Quartz, ilmenite, zircon, kyanite, spinel, staurolite, garnet, tourmaline.

In each case the spinel is in grains of 0·5 to 4 mm. diameter, light bottle-green to greenish black in colour, transparent to opaque in thicknesses of 1 mm., and isotropic. The specific gravity was found to be 3·61. Some grains have recognisable octahedron faces. The original matrix of the mineral is unknown.

* An. Rept. Chem. Branch W.A., 1923, p. 11; Amer. Mineralogist 13, p. 461.

† Mineral Mag. 19, p. 99-106.

(10) TOURMALINE, WODGINA, N.W. DIV.; GREENBUSHES, S.W. DIV.; AND KALGOORLIE, CEN. DIV.

SCHORL (Indicolite), Wodgina. On a dump on the Mt. Cassiterite Tin Mine (M.L. 84) large masses of deep blue tourmaline are plentiful, apparently derived from the biotite-chlorite schist forming the wall of a pegmatite vein. Structurally the masses consist of a compact felt of minute prisms, a fresh fracture showing some portions to be much finer grained than others. The finer portions are coloured "dusky blue" (Ridgway 49* m), the coarser "indulin blue" (51*m). Under the microscope the largest prisms measure about 2 x 0·2 mm, the average being about one quarter that size. O is cornflower blue, E colourless.

An analysis by Mr. D. G. Murray proves that the mineral belongs to the species "schorl," $H_5NaFe_4Al_5B_4Si_8O_{41}$. See table below.

DRAVITE and SCHORL, Greenbushes. A black tourmaline is especially abundant throughout this tin field, most of it forming part of, or being derived from, the tin-bearing pegmatites, those on the Cornwall Lease carrying large proportions of the mineral, and one on the Lost and Found Lease being composed of almost equal parts of tourmaline and albite. A single alluvial boulder of it was found many years ago in Floyds Gully which weighed 40 kilos (90 lbs.). This was composed of a dense mass of coarse prisms, ranging up to 1 cm. in diameter, and of an almost pure black colour (Ridgway's dark or dusky neutral grey). Under the microscope the colours were O, very dark grey blue; E, pale smoke brown.

An analysis made by Mr. H. P. Rowledge of this large boulder shows that the species present is a ferruginous "dravite," $H_5Na(Mg,Fe)_4Al_5B_4Si_8O_4$, the atoms of Mg being nearly twice as numerous as those of Fe″. The figures are given below.

The black tourmaline occurring plentifully in masses up to a centimetre in diameter in a pegmatite vein at 268 ft. on the Cornwall lease was partly analysed to determine its species. Although in outward and microscopic appearance (including pleochroism) it is similar to the large alluvial boulder, the analysis showed the presence of 14·86 per cent. of FeO, when the whole of the iron was calculated to that form, with only 0·51 per cent. of MgO. This mineral therefore is a typical schorl. Its specific gravity is 3.15, slightly greater than the more magnesian mineral.

DRAVITE, Kalgoorlie. An undetermined species of tourmaline is widespread in sporadic small, usually microscopic, prisms in both rocks and lodes at Kalgoorlie. In addition, in a quartz vein in Archaean greenstone at Mt. Hunt is a tourmaline of most unusual appearance. In colour it varies from Ridgway's "pale neutral grey" to "deep neutral grey." In structure it is in very finely fibrous, almost silky masses, up to 15 cm. in length, and from 1 to 10 cm. in width and thickness. At first sight it is not unlike some "mountain wood." A thin slice exhibits a dense mass of practically parallel fibres ranging from 0·02 to 0·04 mm. in diameter and reaching to a centimetre or possibly more in length. They cannot be followed indefinitely in length owing to their slight curvature. In section E is colourless, and O mostly light greyish-green, but also in small part light smoke-brown.

The composition, given below, is that of a ferruginous dravite, not unlike that from Greenbushes, the ratio of MgO to FeO being 2·4 to 1·0.

	Indicolite (Schorl), Wolgina.	Ferruginous Dravite, Greenbushes.	Fibrous Dravite, Kalgoorlie.
SiO_2	36·06	36·02	36·78
TiO_2	*nil*	·58	·40
H_2O + ...	1·98	3·82	3·68
Li_2O	·26	·10	trace
Na_2O	1·76	1·48	2·35
K_2O	trace	·08	·05
MgO	·27	7·81	8·75
CaO	·37	·80	·76
MnO	·35	·21	·20
FeO	10·68	7·17	6·54
Fe_2O_3	1·99	·38	trace
Al_2O_3	35·97	31·45	30·83
Cr_2O_3	*nil*	·05	*nil*
B_2O_3	10·48	10·33	10·06
F	·87	·22	·08
H_2O—	*nil*	·10	*nil*
Total	101·04	100·60	100·48
Less O = F_2 ...	·37	·09	·03
Net total	100·67	100·51	100·45
Sp. gr.	3·15	3·12	3·09
Analysts	D. G. Murray	H. P. Rowledge	E. S. Simpson

(11) VESUVIANITE, TAMBOURAH, N.W. DIV.

The first discovery of vesuvianite in the State has been made near Tambina Creek, six miles north of Tambourah, in Lat. 21° 40′ S., Long. 119° 10′ E. The mineral is in coarsely crystallised groups with brilliant prism faces of a brownish-black colour. Internally the colour is somewhat lighter, inclining towards an olive brown. The largest prism seen is 4 cm. square, both ends being missing. The broad *m* (110) faces are strongly striated by multiple repetition of vicinal faces, and some show a tendency to scale off. The *a* (100) faces are rather narrow, and are accompanied by bevels of *h* (310) and *f* (210). In several crystals the basal plane is intact. A basal section of a small crystal gave a good uniaxial figure, and showed a zonal structure, with the centre light pinkish-brown, the narrow border darker brown. A vertical section showed a very slight pleochroism, X (*c*) very pale green or brown, Z darker brown.

There are two well-recognised varieties of vesuvianite. The normal one contains no boron, or only traces; in "viluite," B_2O_3 substitutes Al_2O_3 to the extent of 2 or 3 per cent. As fluorine has been detected in all vesuvianite in

which it has been looked for, and lithium in several. the Tambourah mineral was carefully tested for boron, fluorine and lithium. The results of the analyses made for me by Mr. D. G. Murray were:

SiO_2	B_2O_3	Al_2O_3	Fe_2O_3	FeO	MnO	MgO	CaO	Na_2O	K_2O
36·75	*nil*	16·51	2·73	3·00	·33	1·55	35·28	·12	·10

Li_2O	H_2O+	TiO_2	F	Total	$O = F_2$	Net total.	Sp. gr.
·06	1·25	2·17	1·80	101·65	·76	100·89	3·42

The formula calculated from the analysis is $Ca_{12}Al_6Si_{11}(OH,F)_{10}O_{31}$; the molecular ratios being as follow. Against them are tabulated the ratios accepted by various authorities:—

——	Tambourah.	Dana.	Hintze.	Winchell.
SiO_2	10·58	10	35	8
M_2O_3	2·96	3	10	2
MO	11·80	12	40	8
(OH, F)	3·89	4	14	4

The only associated minerals observed were quartz and travertine. No information is available regarding the mode of occurrence at Tambourah, but the district is known to be occupied by Archaean granite and greenstone.

By Authority: JOHN LEE, Acting Government Printer, Perth.

16.—THE WATER EXTRACTS OF WESTERN AUSTRALIAN SOILS.

No. 1.

Studies on Soils from Merredin, Ghooli, Salmon Gums, Wongan Hills, Chapman, Baker's Hill and Lake Brown.

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(*Read* 4th May, 1929. *Published* 25th July, 1929.)

INTRODUCTORY.

In presenting the subject of the composition of the water extracts of certain of the soils of this State to the people of Western Australia, it seems desirable, at the outset to touch upon the main ideas and contributions which have led to the present status of our knowledge in this field. It is the object of the writer to prove in these introductory remarks the importance of the soil solution as the direct source of at least the bulk of the minerals absorbed by plants. It will be shown that the subject is not new and that direct contributions have been made since about 1860.

The first advances in the science of plant nutrition were due to the efforts of Theodore de Saussure (4)* a Swiss who published his views and experimental data in 1804. He showed *quantitively* that certain minerals were absorbed from the soil and that the carbon dioxide of the air supplied the carbon needs of plants. De Saussure's views were not acceptable to the agricultural chemists of the day and it was not until the great German chemist Justus von Liebig (8), some 30 years later adopted the main features of his thesis and embodied them in his forceful writing, that the knowledge of the mineral requirements of plants was of much interest to investigators. Many of the essentials of Liebig's teachings are acceptable to-day.

However, Liebig believed that the aqueous solution in the soil was inadequate to supply the mineral needs of plants. He argued, in 1863, that "the power of the soil to nourish cultivated plants is therefore in exact proportion to the quantity of nutritive substances which it contains in a state of physical saturation." (Russell, E. J., "Soil conditions and Plant growth," 1921, p. 151). Also he believed that the yield was governed by the necessary constituent in least amount (physiologically) in the soil—(Law of the minimum). Unfortunately, the great complexity of the soil

* Figures in brackets refer to literature cited.

system was not realised at this time and in the course of a few years the results of the field experiments of Lawes and Gilbert at Rothamsted and of Ville and others in France led to the discrediting of Liebig's "Mineral Theory."

Meanwhile certain agricultural chemists and others interested in the subject were busily studying the liquid phase of the soil. Eichhorn (5) in Germany, used the water extraction method to study a soil from Bonn and concluded, from his results, that the soil contained sufficient water soluble constituents to meet the needs of a growing crop. Although these results were criticised by Liebig's followers, other workers in Germany were able to substantiate Eichhorn's views. The next great advance was made in France by Schloesing (13) who studied the solutions *displaced* from the soils by allowing coloured rain water to percolate through a compact column of moist soil. This method, with modifications and improvements, has been one of the most fruitful in affording information concerning the soil solution. Schloesing and his son (14) concluded that the soil solution supplied at least the major portion of the mineral constituents absorbed from the soil by plants.

The question of root secretions is still with us. Liebig (8) believed that acetic acid excreted by the roots *dissolved* the absorbed minerals. Early investigators placed much importance on the experiment showing the etching of polished marble by growing roots. However, Czapek (3) in 1896 showed that the effect was due to carbonic acid, because, in the first place, plates made of aluminium phosphate and plaster of Paris were not attacked, thus eliminating acids stronger than citric, tartaric or malic; in the second place, the secretions turned congo red a brownish red. The presence of acetic acid causes the development of a blue colour while carbonic acid produces the brownish red colour with congo red as obtained. Recent work by F. W. Parker (9, 10) indicates that there is no relation between absorption of minerals and the total production of carbon dioxide in a soil. However, no one has yet been able to measure the effectiveness, if any, of the carbon dioxide produced by the root hairs in intimate contact with the soil particles. Be that as it may, the soil solution (as extracted from the soil) seems to approximate the "physiological" soil solution.

The concentration of the soil solution is due in part to the solvent action of water on the soil minerals, and in greater measure to the nitric and sulphuric acids produced by bacteria as end products in the decomposition of organic matter. Soils differ greatly in respect to both the composition and concentration of the solution and in general the sequence of vegetation types in any one zone is related in particular to the nature of the soil solution.

It is interesting to note that an error on the part of certain prominent American investigators led to renewed activity in soil solution studies in the early part of the present century. Whitney and Cameron (16) argued that, as most soils contain practically the same minerals in the solid phase, the soil solution must be a saturated solution of these minerals and must be practically uniform in composition and concentration in all soils. This was perfectly good chemistry, but was in error as the propounders overlooked the fact that the soil is primarily a biological laboratory. In

a short time papers appeared, notably from Rothamsted (6) and the United States, controverting this thesis. At the present time, a bibliography of the important papers on the soil solution would run into hundreds. The principal contributions now come from America, Germany and Russia. Several States in Australia are using methods of studying the soil solution in connection with their problems.

The concentration of the solution in most soils ranges from about 100 p.p.m. to 4,000 p.p.m. of the soil solution. Expressed in terms of the dry soil this would amount to from 20 to 800 p.p.m. Alkali soils are not normal as the solution is excessively enriched as a result of outside agencies such as seepage and evaporation, deposition of salts in the rain, etc. Typical examples of the concentration and composition of the soil solutions from American soils are given in Table 1. It will be seen that the soil solution is by no means of constant composition or concentration. Also the bulk of the anions (nitrate and sulphate) are of biological origin.

TABLE 1.

THE COMPOSITION OF THE SOIL SOLUTION.

ppm Soil Solution.

Soil.	pH.	SO_4.	NO_3.	Cl.	PO_4.	Ca.	Mg.	K.
California 7B	7·6	454	1.781	55	1·2	672	134	38
California 33 (15)	7·0	...	50	...	0·2	50	...	...
California Madera	7·3	140	47	...	4·5	119	129	57
Oregon 1	...	Trace	75	...	...	83	...	15
Oregon 2	...	50	137	...	...	64	...	12
Rothamsted (6)	...	...	...	...	0·6	...	...	3· 4

Of course this Table does not give a complete picture of the soil solution. In addition to these substances will be found about fifteen elements among which are iron, manganese, iodine, nickel, zinc, boron, aluminium, silicon, vanadium, copper, etc. These elements are present in minute amounts but normally in physiologically sufficient quantities.

The use of amendments of various kinds to increase the soil fertility has been practised since earliest times. The amendments may have a physical effect, a chemical effect, or most probably, both. The simplest fertiliser works profound changes in the composition of the soil solution, as a result of direct chemical reactions with the soil and also as a result of changed biological conditions. Thus lime not only neutralises acidity or sourness, but increases the phosphate content of the soil solution in many instances. In addition, potassium, magnesium and other elements may be brought into solution while others, *e.g.*, manganese are precipitated causing physiological disorders such as chlorosis. A study of Table 2 indicates the complexities of fertiliser treatments and also that fertilisers directly increase the concentration of various elements in the soil solution.

Table 2.

EFFECT OF FERTILISERS ON THE COMPOSITION OF THE SOIL SOLUTION.

ppm Soil Solution.

*ppm Dry Soil—Water extract.

—	pH.	PO_4.	SO_4.	NO_3.	Ca.	Mg.	K.	Na.	Mn.
California 30 (15)—									
Untreated ...	7·0	7·2	97	576	207	64	...	...	0·16
Sulphur (1500 ppm 90 days)	3·2	38·0	8920	536	600	1310	...	...	250
Oregon (11)—									
Untreated ...	6·2	4.0	253	116	144	119	98	...	...
K_2SO_4 (540 lbs. per acre)	6·1	3·0	294	157	116	113	172	...	...
Untreated ...	6·7	4·0	161	70	172	91	60	...	...
$(NH_4)_2SO_4$ (410lbs. per acre)	5·4	4·0	205	150	227	121	63	...	...
California 1C *(1)—									
Untreated ...	...	5·3	125	297	105	38	42	96	...
$22K + 77NO_3 + 10PO_4$	...	4·6	159	338	119	56	49	115	...
$75K + 117NO_3 + 61PO_4$	...	8·6	278	350	126	44	80	102	...
$435K + 687NO_3 + 357PO_4$	...	30·0	692	692	237	102	165	112	...
Tankage ...	...	6·7	153	592	146	52	61	110	...

The effect of the crop in modifying the soil solution has been amply discussed in papers from the University of California (11, 2). As a result of crop growth the soil solution is practicaly depleted of nitrate, while calcium, potassium, phosphate, etc., are significantly reduced in concentration.

Having discussed the soil solution as the phase of immediate physiological importance some brief mention must be made of the methods in use for obtaining the soil solution for purposes of study.

1. The Water Extract.

The soil is extracted with a known proportion of distilled water and filtered. The filtrate is then examined by the usual chemical methods. Studies by Stewart (14) Hoagland et al (7) indicate that the water extract gives a very good picture of the true soil solution. As no special apparatus is required this method has been adopted in the studies here reported. In order to minimise the direct solubility effects on the soil minerals, a narrow ratio of one part of soil to two parts of water is used.

2. The displaced solution is obtained by modifications of Schloesing's (12) method, using alcohol, kerosene or water as the displacing medium and air pressure to increase the rate of displacement.

3. The expressed solution probably accurately represents the true soil solution. The moist soil is pressed in a hydraulic press and the liquid obtained analysed.

In addition to these more or less direct methods, the concentration of the soil solution may be determined indirectly by the use of physical methods. The total concentration may be computed from the freezing point lowering the soil and the content of electrolytes by measurement of the resistance to the flow of electricity through the soil or soil extract.

1.—Studies on Soils from the State Farms at Merredin, Ghooli, Salmon Gums, Wongan Hills, and Chapman, and from Baker's Hill and Lake Brown.

The Soils used.

The soils from the State Farms were obtained from the headlands adjacent to the Rate of Superphosphate plots in 1928. The surface soil (A. horizon) was sampled at five different places along the width of the plots and a composite sample made. The following general observations describe the soils used:-

1. *Merredin.*—A dark brown clay loam from 10in. to 12in. deep. The marked accumulation of clay and calcium carbonate below this depth indicates a mature profile. The main timber was Salmon gum (Eucalyptus salmonoploia) and Gimlet (E. salubris).
2. *Ghooli.*—a red silty clay loam from gently rolling forest land.
3. *Salmon Gums.*—Greyish brown, calcareous loam, bearing mallee. This soil contains an appreciable amount of sodium chloride and represents a type of mallee lands of the Esperance area.
4. *Wongan Hills.*- A grey sand containing a small amount of sticky clay. The soil carried a low scrub and represents one of the many types of light lands of Western Australia.
5. *Chapman.*- A red sandy loam from a small flat near a creek. It was probably formed through the agency of the creek and is of "recent" origin. The soil is formed from rocks of the granite type and carried jam (Acacia acuminata) with some scrub.
6. *Baker's Hill.*—The soils represent two types from the higher levels of the Darling Range. Samples 1, 2, and 3 are white sands while sample 4 is a black creek bottom soil.
7. *Alkali Soils.*—Representing samples from Lake Brown. Samples 2, 3, 4, and 8 are chocolate soils of a silt loam texture carrying a Morrell (Eucalyptus sp.) as the principal timber. Sample 10 represents a fertile dark brown clay loam carrying gimlet (E. salubris) and is given for purposes of comparison.

The Composition of 1 : 2 Water Extract.

The extract was prepared by mixing one part of soil with two parts of water by weight and filtering under suction. The extracts were analysed by standard methods adapted for the purpose. The reactions expressed as pH were determined colorimetrically. The results of the analyses are reported in Tables 3 and 4.

TABLE 3.

COMPOSITION OF WATER EXTRACTS OF SOILS OF WESTERN AUSTRALIA

	1 : 2 WATER EXTRACTS.			ppm Dry Soil.				
Locality.	pH.	NO_3.	SO_4.	PO_4.	Cl.	HCO_3	Ca.	Mg.	Mn.
Merredin	7·4	193	41	?	204	20	31	125	*Nil*
Ghooli	7·4	59·5	...	?	196	108	11	...	*Nil*
Salmon Gums ...	8·0	39·7	...	?	568	390	14	...	*Nil*
Wongan Hills ...	7·1	10·9	31	?	50	34	13·5	9	Trace
Chapman	6·4	5·9	19	?	24	36	18	10	*Nil*
Baker's Hill—									
1	6·6	19	...	Trace	20	32	0	6·2	...
2	6·6	22	...	0·09	20	32	0	5·2	...
3	6·9	38	...	0·12	8	36	0	1·4	...
4	7·2	26	...	0·06	28	44	6·0	6·2	...

Table 4.

COMPOSITION OF WATER EXTRACTS OF ALKALI SOILS (WEST. AUS.).

1 : 2 Water Extracts.

ppm Dry Soil.

(Analyses made by Government Analyst, 24–10–28.)

—	pH.	NO_3.	SO_4.	Cl.	CO_3.	Ca.	Mg	K.	Na.
Lake Brown—									
2 and 3 ...	7·6	602	426	1,698	84	161	96	44	1,199
4 and 8 ...	7·9	205	158	889	108	113	34	57	583
10 (normal) ...	8·4	43	112	387	126	30	14	Trace	356

Further details on soils from Esperance and Kellerberrin may be obtained from Professor Paterson's Report to the Royal Commission on the Mallee Belt and Esperance Lands, 1917.

Several features are worthy of note:—

Table 3.

1. A very high content of nitrate in the Merredin soil. This figure corresponds to about 1,200 ppm in the soil solution and compares with rich alluvial soils of California (7B, Table 1).

2. The poverty of the Wongan Hills and Chapman soils with respect to nitrate.

3. An almost complete absence of soluble inorganic phosphate in all soils. Top dressing of the Baker's Hill samples 2 and 3, probably accounts for the presence of soluble phosphate in these soils.

4. A deficiency of soluble calcium, as well as phosphate, in the sandy soils from Baker's Hill. The combination of these deficiencies is undoubtedly of great physiological significance and is suggestive as to a factor in the disorders among stock in the region.

5. Of the soils tested, the Wongan Hills soil was the only one from which a test for soluble manganese was obtained. Recent studies have shown this soil to be more than indicated by the 1 : 2 water extract, and the acid reaction (pH 5.6) is probably responsible for the higher content of soluble manganese.

Table 4.

The analyses were made by the Government Analyst on these soils and the figures are presented to illustrate the essential character of alkali soils a concentrated soil solution. In these soils the bulk of the soluble material consists of sodium chloride. The soils are also rich in nitrate, potassium, calcium, etc., in solution, and would be very fertile but for the excess of sodium chloride. The analyses of sample 10 are given so that the alkali soils may be compared with a normal forest soil from Lake Brown.

The Effect of Additions of Soluble Phosphate.

It was thought that interesting results would be obtained from a study of the effect of phosphatic applications on the composition of the water extracts of soils from the State Farms. Three samples of each soil were taken and treated as follows:—

1. Moistened with distilled water to the optimum moisture capacity.
2. Moistened with distilled water containing phosphate equivalent to 52.4 p.p.m. of the dry soil.
3. Moistened as above, the phosphate being equivalent to 262 p.p.m. of the dry soil.

A solution of sodium phosphate was used as the source of phosphate.

The moist soils were stored in the laboratory and water extractions made after periods of one month and four months from the date of mixing.

Results of the analyses are reported in Table 5.

TABLE 5.

EFFECT OF ADDITIONS OF SOLUBLE PHOSPHATE ON THE WATER EXTRACT OF SOILS FROM WESTERN AUSTRALIA.

Soils were moistened with distilled water and with solutions of sodium phosphate. Analyses were made after standing for one month and four months after treatment.

(ppm Dry Soil.)

	Distilled Water.		52·4 ppm PO_4 added.		262 ppm PO_4 added.	
	After 1 month.	After 4 months.	After 1 month.	After 4 months.	After 1 month.	After 4 months.
Merredin—						
PO_4 ppm	?	?	...	1·1	32	17·6
NO_3 ppm	193	206	182	208	190	190
Ghooli—						
PO_4 ppm	?	?	...	0·94	25	13·1
NO_3 ppm	59·5	171	54·5	72·6	50·6	83·2
Salmon Gums—						
PO_4 ppm	?	?	...	0·86	35	20·9
NO_3 ppm	39·7	44·0	45·6	45·6	30·7	37·6
Wongan Hills—						
PO_4 ppm	?	?	...	0·55	32·5	6·2
NO_3 ppm	10·9	16·8	Lost	48·0	10·9	45·6
Chapman—						
PO_4 ppm	?	?	3·6	0·63	50	22·1
NO_3 ppm	5·9	4·0	1·0	10·9	*Nil*	24·5

In each case the addition of soluble phosphate increased the amount of water soluble phosphate in the soil, but the bulk of the added phosphate was precipitated. The Wongan Hills soil, although a sandy soil, caused the greatest amount of precipitation.

This is probably due to the acid nature of the soil, such cations as manganese, iron and aluminium being effective agents for the precipitation of phosphate at this reaction (pH 5.64). The precipitation in the other soils was probably due to calcium and magnesium ions.

The additions of phosphate affected nitrification only in those soils which appeared naturally poor in nitrate—namely, those from Chapman and Wongan Hills. Approximately fourfold increases in nitrate were obtained in these soils as a result of the phosphate additions stimulating the soil micro-organisms.

These results suggest certain benefits from the superphosphate applications so general in Australia.

1. The soil solution is enriched in phosphate, the normal soil being extremely poor in soluble phosphate.

2. The improved phosphate supplies stimulate nitrification, particularly in soils lacking in nitrate.

3. By drilling the phosphate with the seed a concentrated phosphate solution is obtained in the immediate vicinity of the rootlets. Investigations have shown that soluble phosphate is needed in the early stages of crop growth.

SUMMARY AND CONCLUSIONS.

A general account of the work on the soil solution and the means of studying it has been given.

Work done on Western Australian soils, using the 1 : 2 water extract, is reported and the following conclusions suggested:—

1. The soils studied show a very wide variation in the concentration and composition of the soil solution as illustrated by the water extract.

2. There is almost complete absence of soluble phosphate from the soils under consideration.

3. Darling Range soils may be deficient in soluble calcium as well as soluble phosphate.

4. Additions of soluble phosphate increase the concentration of the water extracts with respect to phosphate. The acid "light lands" soil from Wongan Hills possessed the greatest power of precipitating phosphate in the range investigated.

5. Of those tested, manganese was present in the water extract of the acid soil from Wongan Hills only.

6. Sodium chloride is the predominant salt of certain alkali soils of Western Australia. The alkali soils from Lake Brown were rich in the minerals required for crop growth.

The analytical work performed by the writer was executed in the laboratory of Professor Paterson at the University of Western Australia, to whom grateful acknowledgment is made.

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